

The California - Nevada Drought.

Update: 24 August 2016

Kelly T. Redmond

Regional Climatologist

Western Regional Climate Center

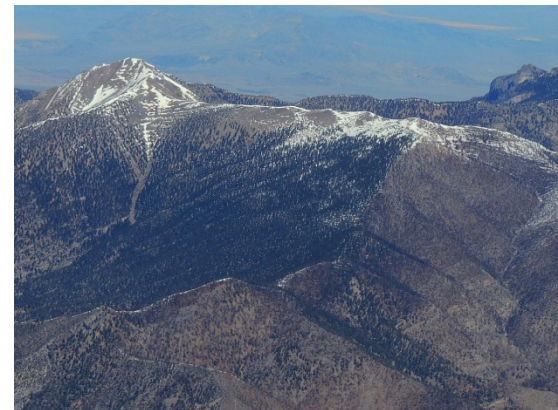
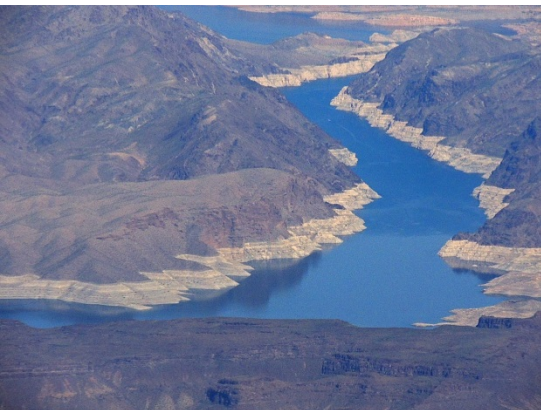
Desert Research Institute

Reno Nevada

Drought Webinar

California - Nevada Applications Program

24 August 2016



Western Regional
Climate Center



Outline

How did we get here?

Current status

Unusual aspects of the current drought

What can we say about the upcoming winter ?

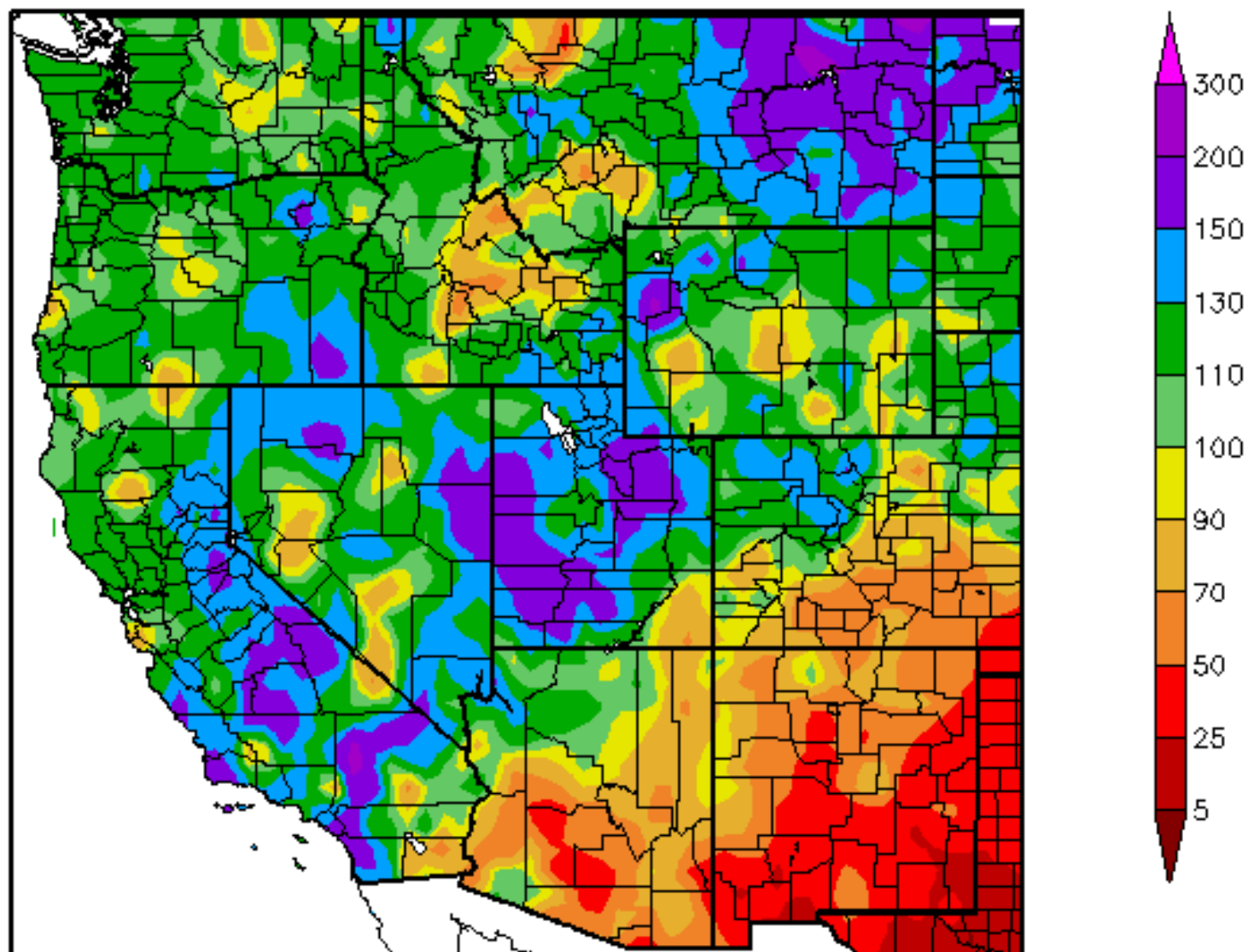
The rise of La Nina ... Implications ???

Near term strategies (late summer into early winter)

Discussion

Water Year
2010-11
01 Oct 2010
Thru
30 Sep 2011

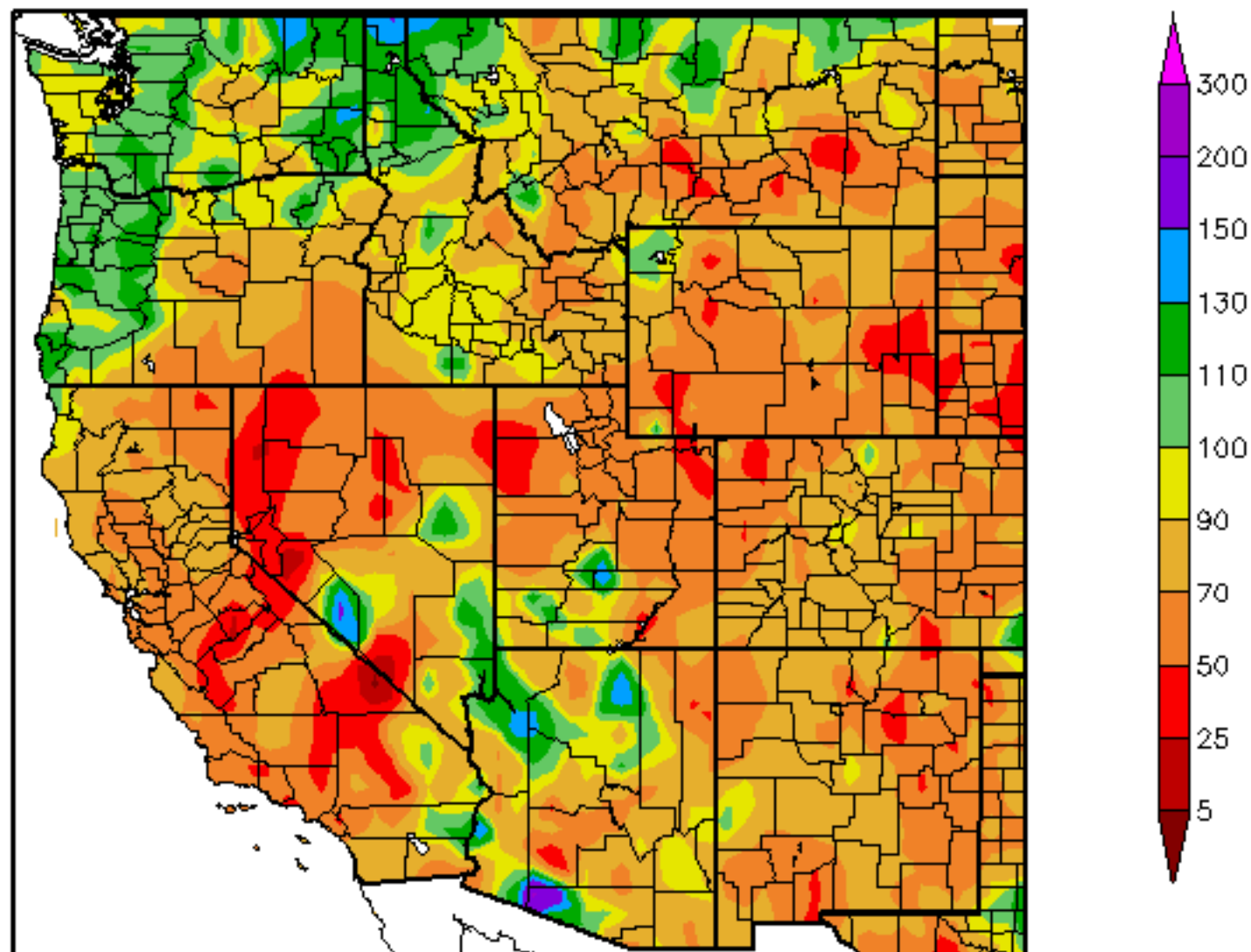
Percent of Normal Precipitation (%)
10/1/2010 - 9/30/2011



Water Year
2011-12
01 Oct 2011
Thru
30 Sep 2012

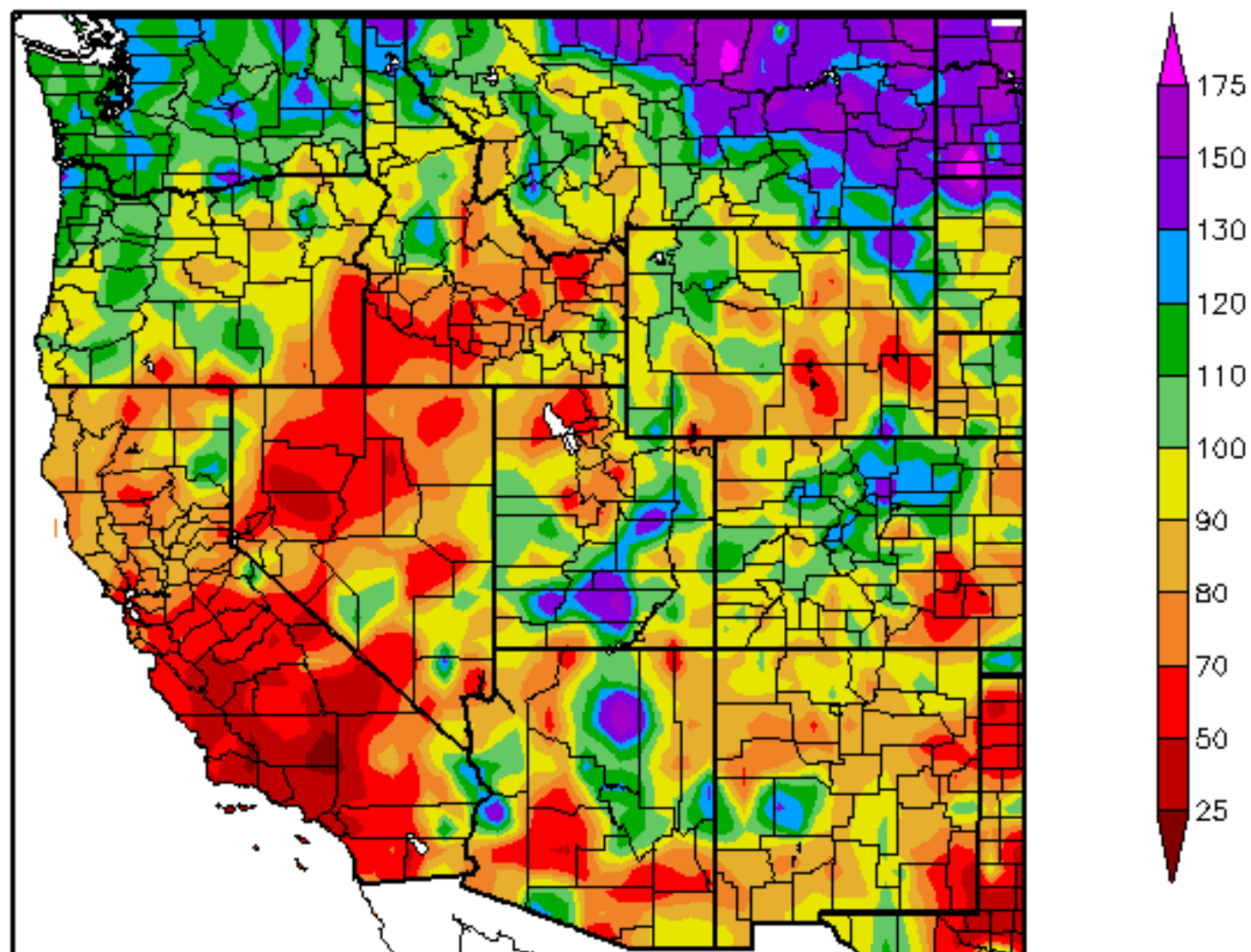
Percent of Normal Precipitation (%)

10/1/2011 – 9/30/2012



Water Year
2012-13
01 Oct 2012
Thru
30 Sep 2013

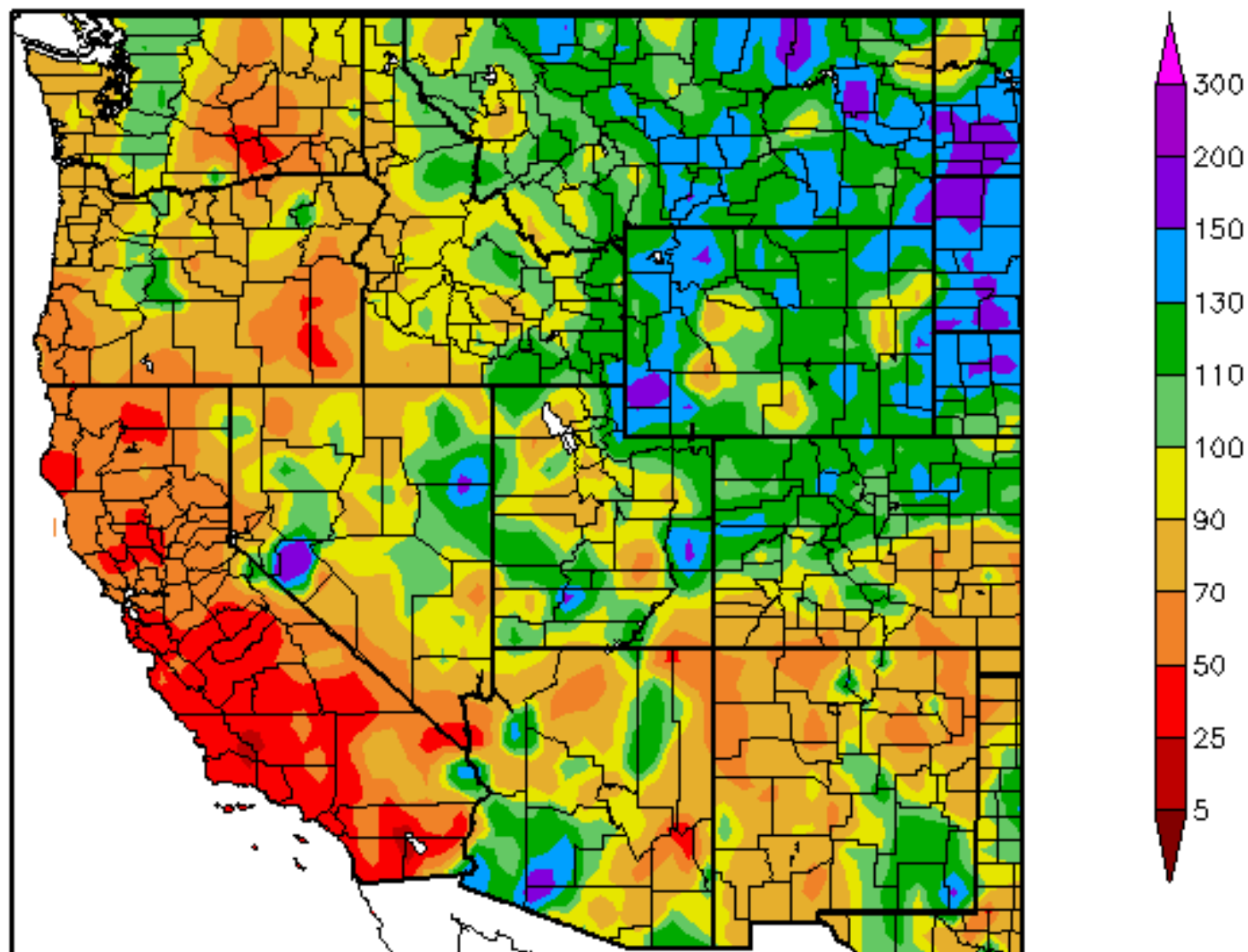
Percent of Normal Precipitation (%) 10/1/2012 - 9/30/2013



Water Year
2013-14
01 Oct 2013
Thru
30 Sep 2014

Percent of Normal Precipitation (%)

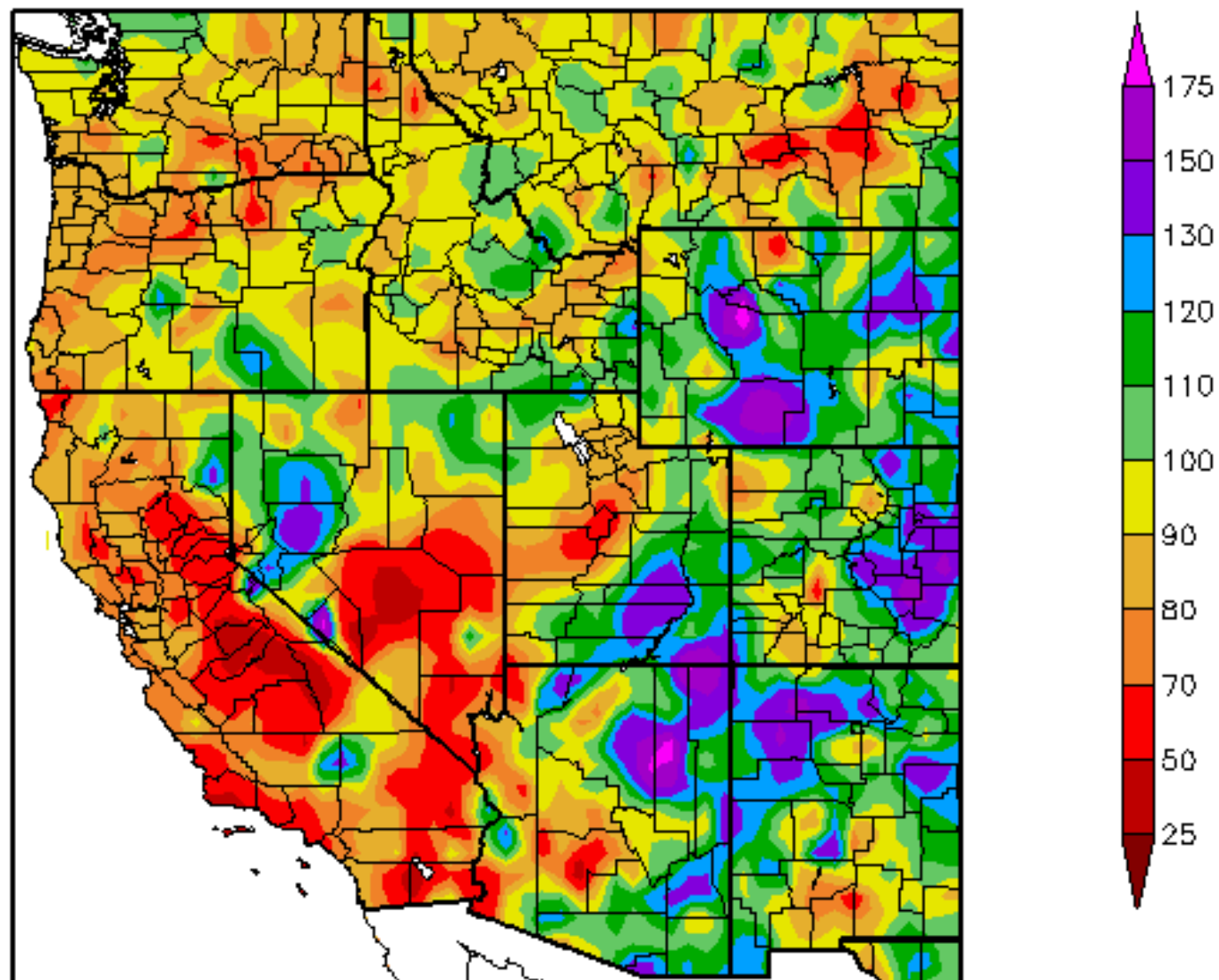
10/1/2013 – 9/30/2014



Water Year
2014-15
01 Oct 2014
Thru
30 Sep 2015

Percent of Normal Precipitation (%)

10/1/2014 – 9/30/2015

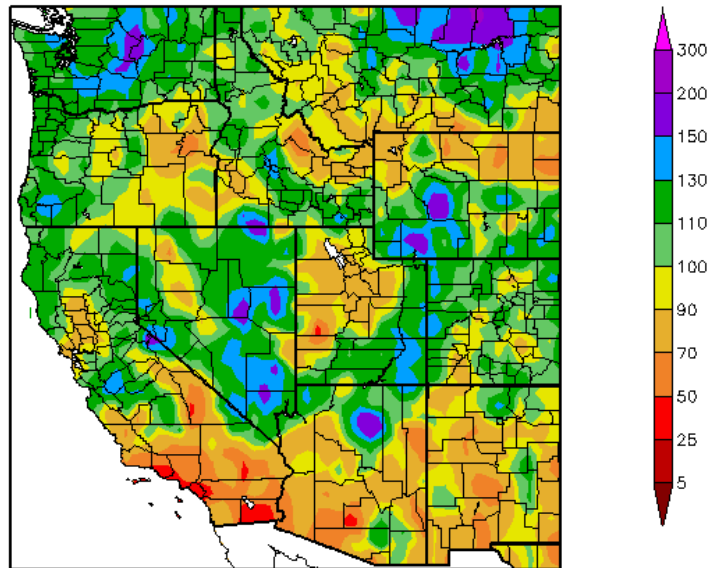


Oct 1 - Aug 20

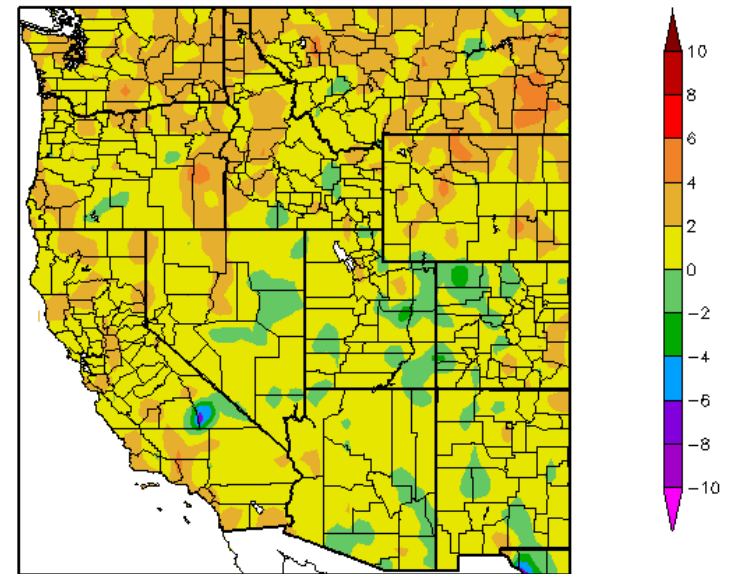
Water Year to Date 2015-2016

Oct 1 - Aug 20

Percent of Normal Precipitation (%)
10/1/2015 - 8/20/2016



Departure from Normal Temperature (F)
10/1/2015 - 8/20/2016



Generated 8/21/2016 at HPRCC using provisional data.

Regional Climate Center Generated 8/21/2016 at HPRCC using provisional data.

Regional Climate Centers

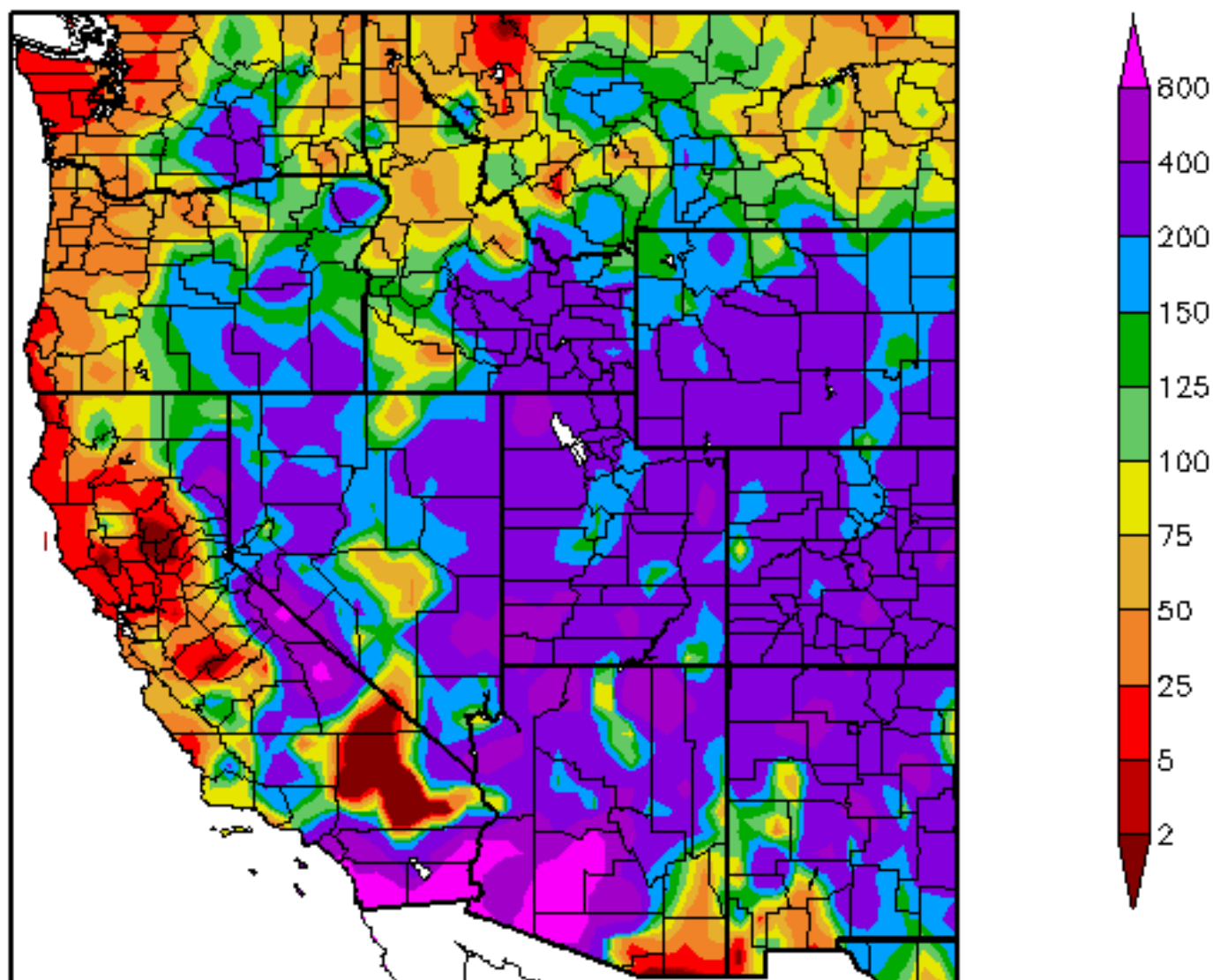
Precipitation Percent

Temperature Departure (F)

May 2015
Precipitation
Percent of
Normal

Percent of Normal Precipitation (%)
5/1/2015 – 5/31/2015

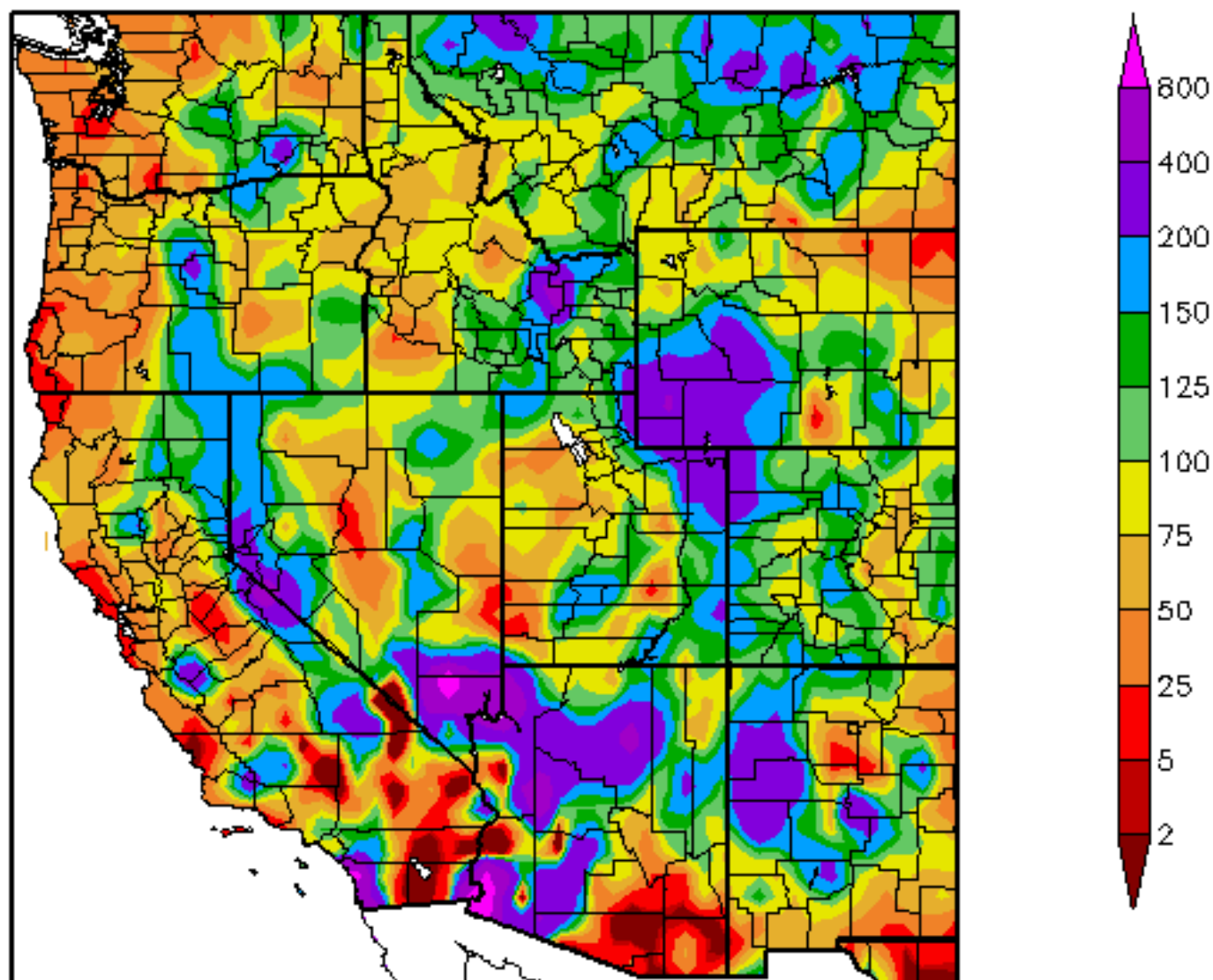
01 May 2015
Thru
31 May 2015



May 2016
Precipitation
Percent of
Normal

Percent of Normal Precipitation (%) 5/1/2016 – 5/31/2016

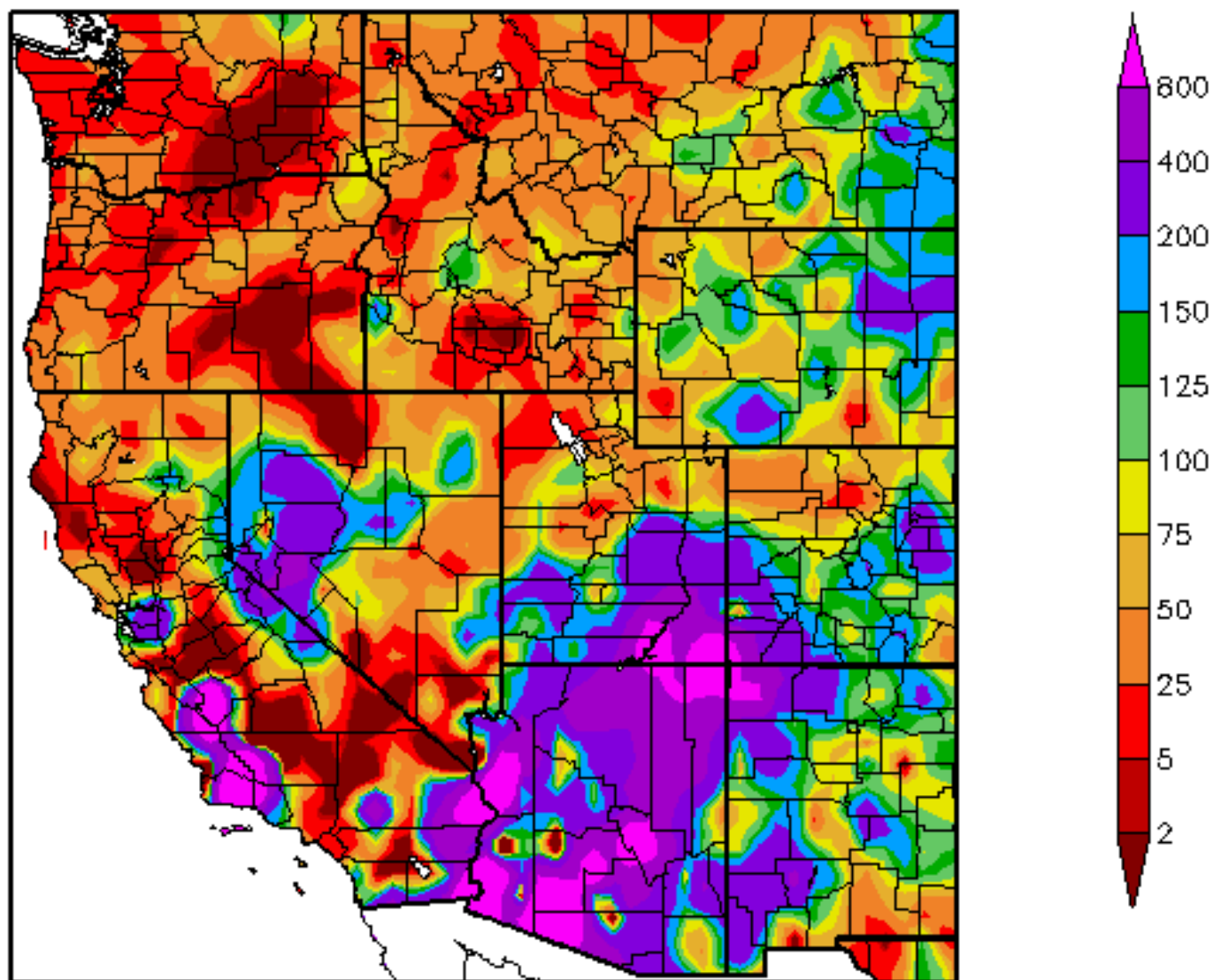
01 May 2016
Thru
31 May 2016



June 2015
Precipitation
Percent of
Normal

Percent of Normal Precipitation (%)
6/1/2015 – 6/30/2015

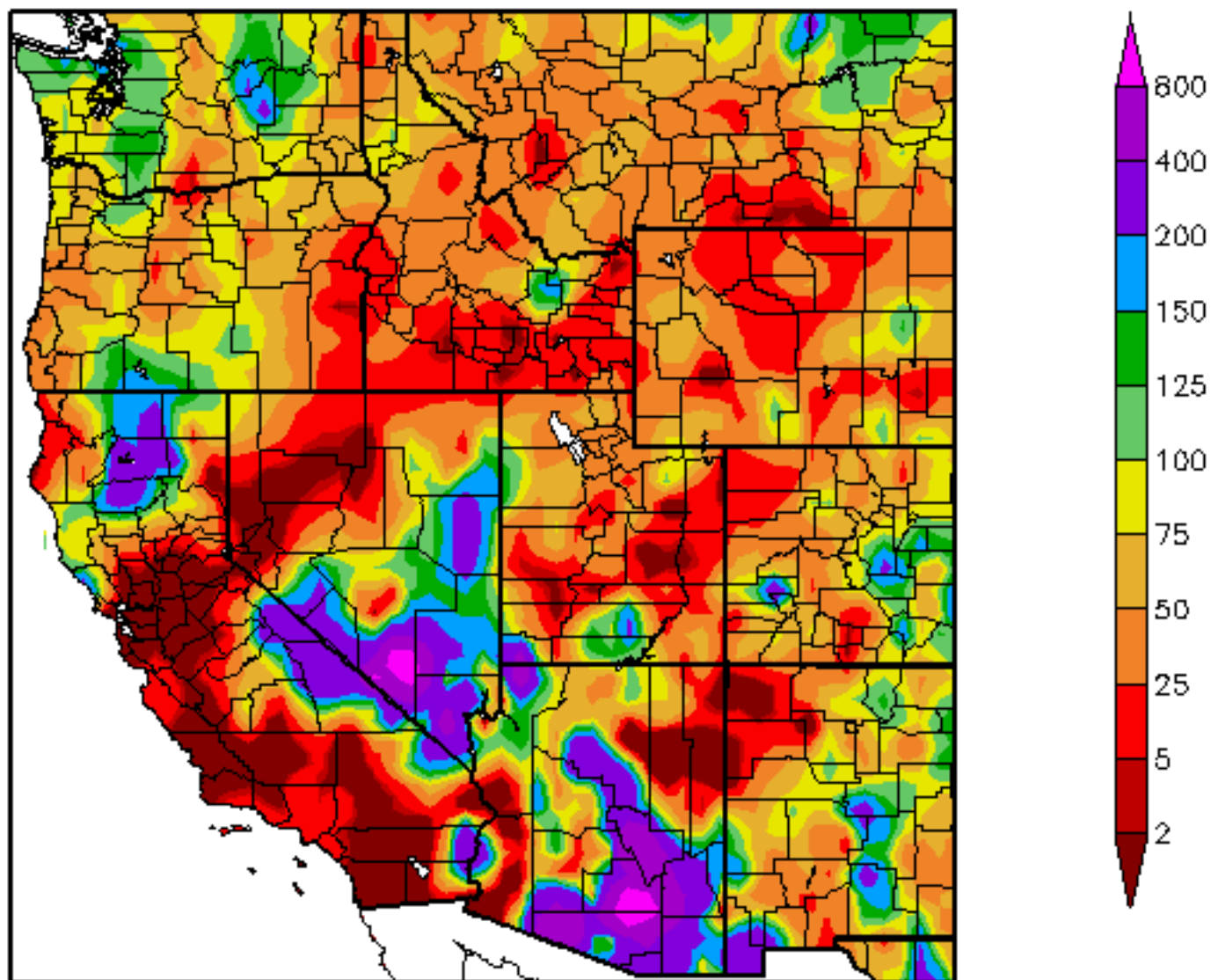
01 June 2015
Thru
30 June 2015



June 2016
Precipitation
Percent of
Normal

Percent of Normal Precipitation (%)
6/1/2016 – 6/30/2016

01 June 2016
Thru
30 June 2016

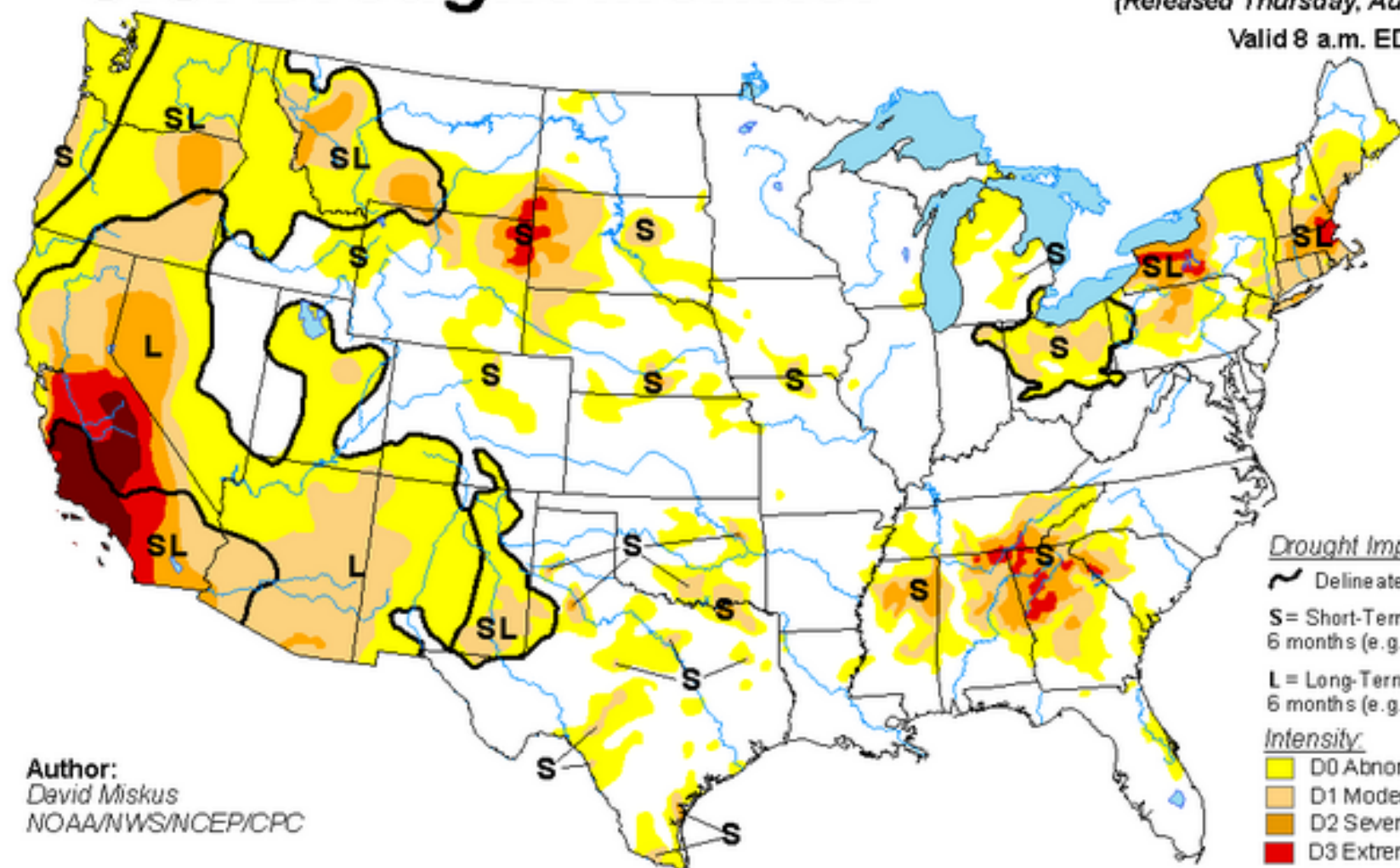


U.S. Drought Monitor

August 16, 2016

(Released Thursday, Aug. 18, 2016)

Valid 8 a.m. EDT



Author:
David Miskus
NOAA/NWS/NCEP/CPC

Drought Impact Types:

~ Delineates dominant impacts

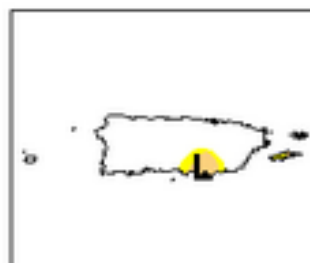
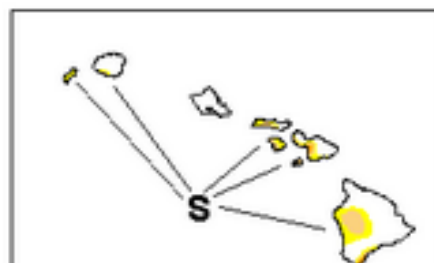
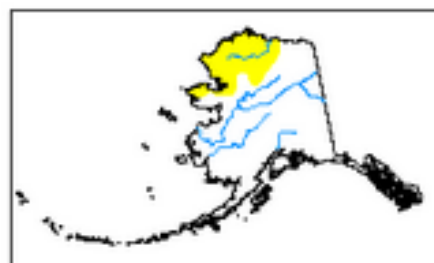
S = Short-Term, typically less than 6 months (e.g. agriculture, grassland)

L = Long-Term, typically greater than 6 months (e.g. hydrology, ecology)

Intensity:

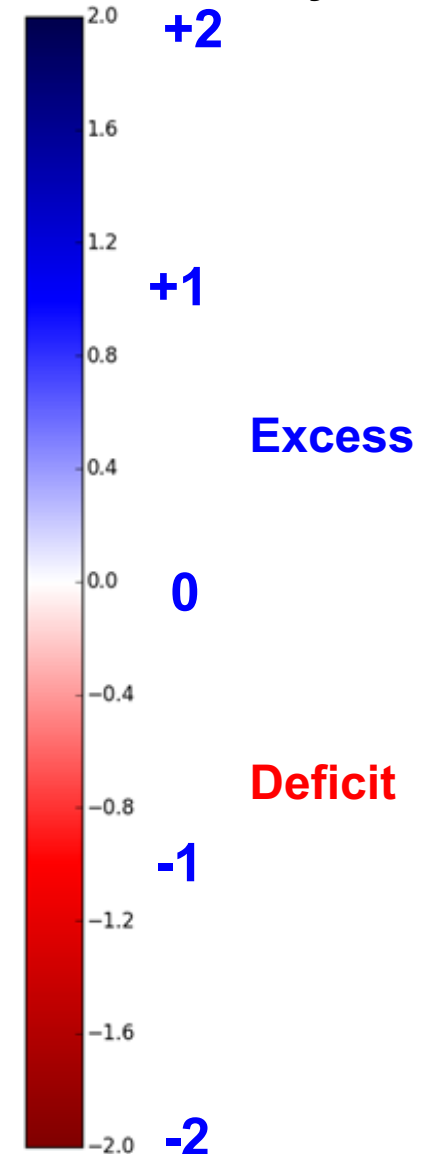
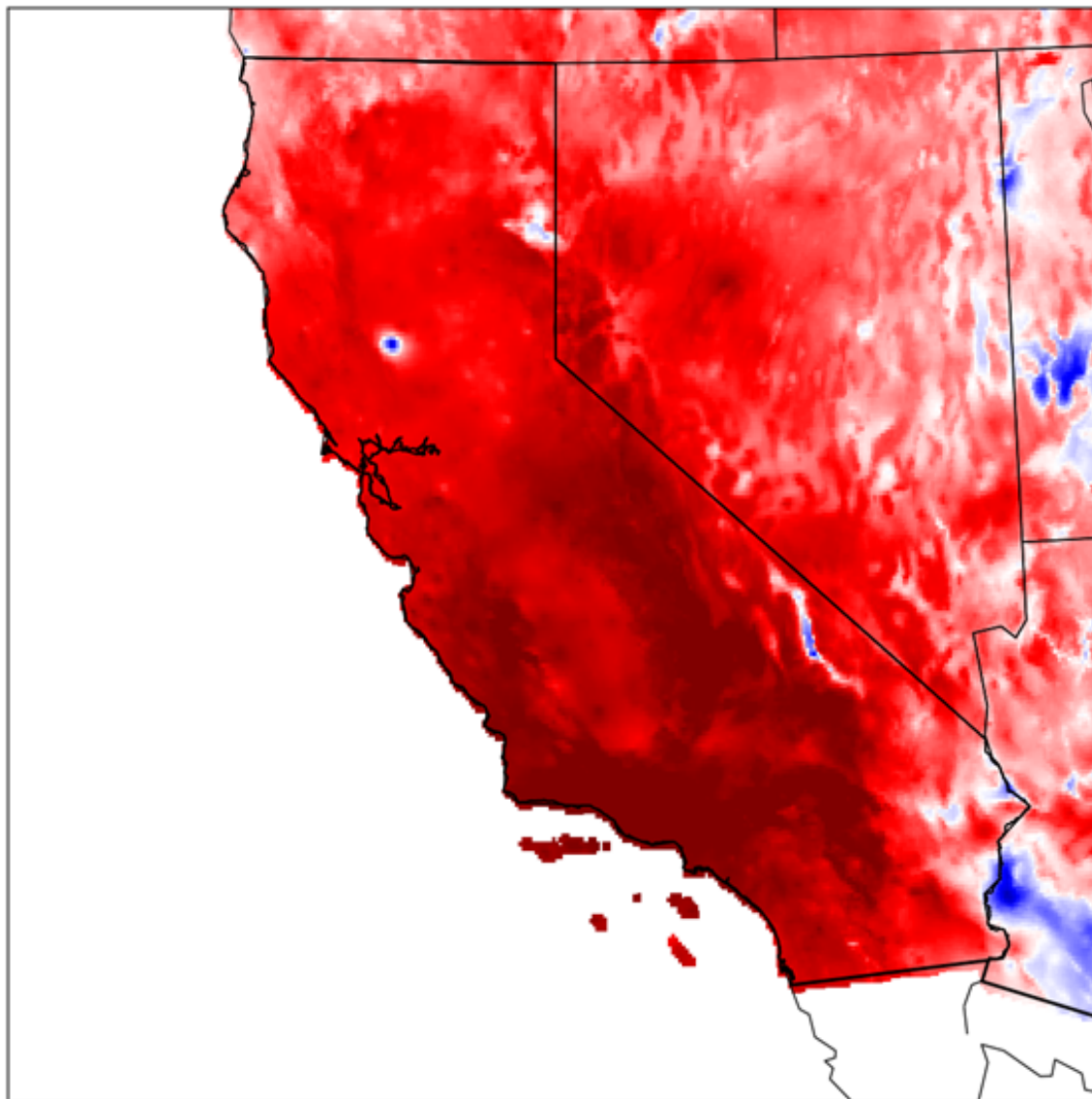
- D0 Abnormally Dry
- D1 Moderate Drought
- D2 Severe Drought
- D3 Extreme Drought
- D4 Exceptional Drought

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary and forecast statements.



<http://droughtmonitor.unl.edu>

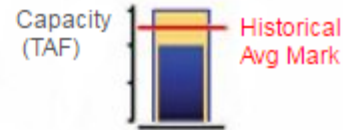
**The Missing Years:
Precipitation Deficits Over Four Winters 2011-12/14-15
Expressed in Units of Average Annual Precipitation.
Based on PRISM. Courtesy Paul Iniguez, NWS Phoenix.**



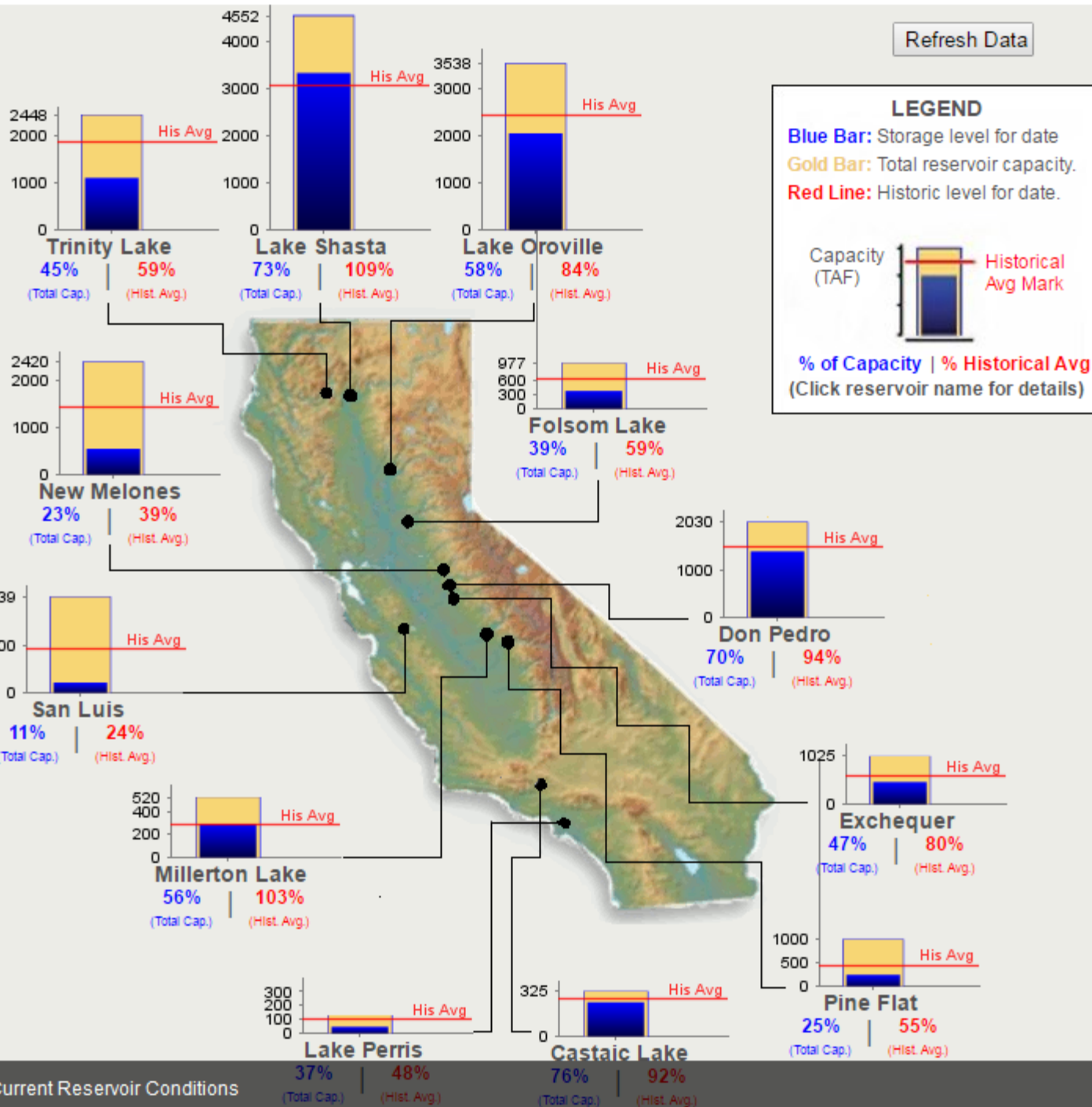
Refresh Data

LEGEND

Blue Bar: Storage level for date
Gold Bar: Total reservoir capacity.
Red Line: Historic level for date.



% of Capacity | % Historical Avg
(Click reservoir name for details)



**Reservoir Update
2016 August 21**

**California Water
Resources Dept**

Sierra Region Precipitation Oct-Sep

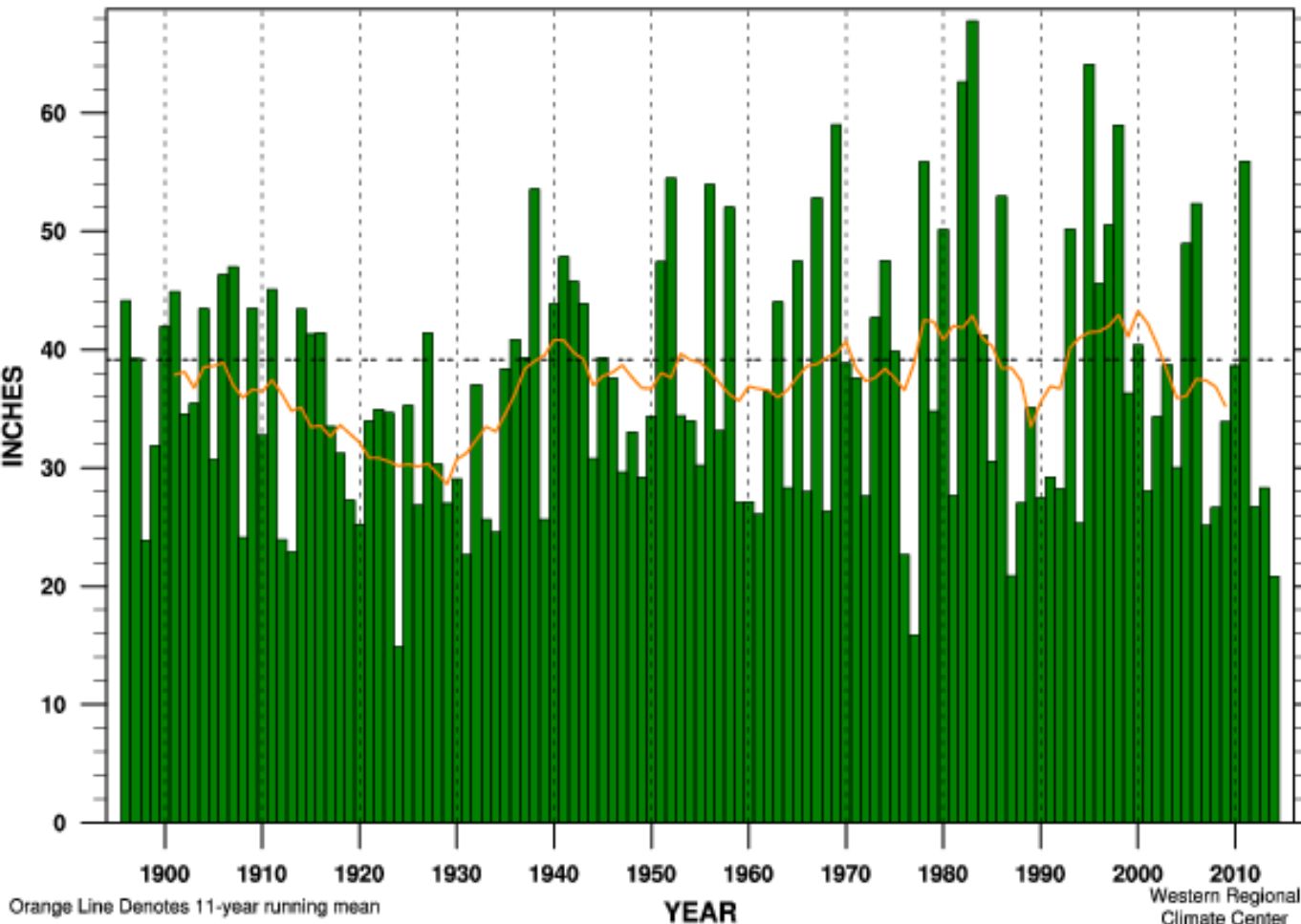
Sierra Nevada Precipitation

Water Year

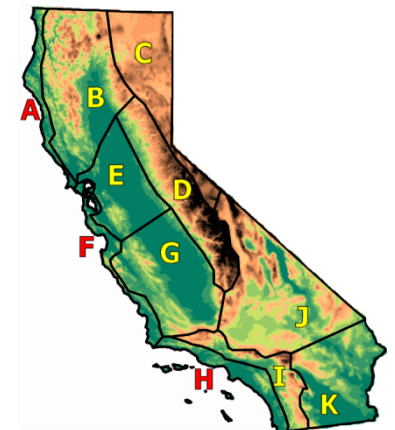
Oct-Sep

1895-96
thru
2014-15

California
Climate Tracker



Linear Trend 1895-present	+ 3.32 ± 5.69 in.	(+ 8 ± 14%) per 100 yr	
Linear Trend 1949-present	- 3.85 ± 16.39 in.	(- 9 ± 41%) per 100 yr	
Linear Trend 1975-present	-11.68 ± 39.68 in.	(- 29 ± 101%) per 100 yr	
Wettest Year	67.79 in. (173%) in 1983	MEAN	39.15 in.
Driest Year	14.89 in. (38%) in 1924	STDEV	12.33 in.
Oct-Sep 2014	20.81 in. (53%)	RANK	3 of 119



Sierra Region Precipitation Oct-Jul

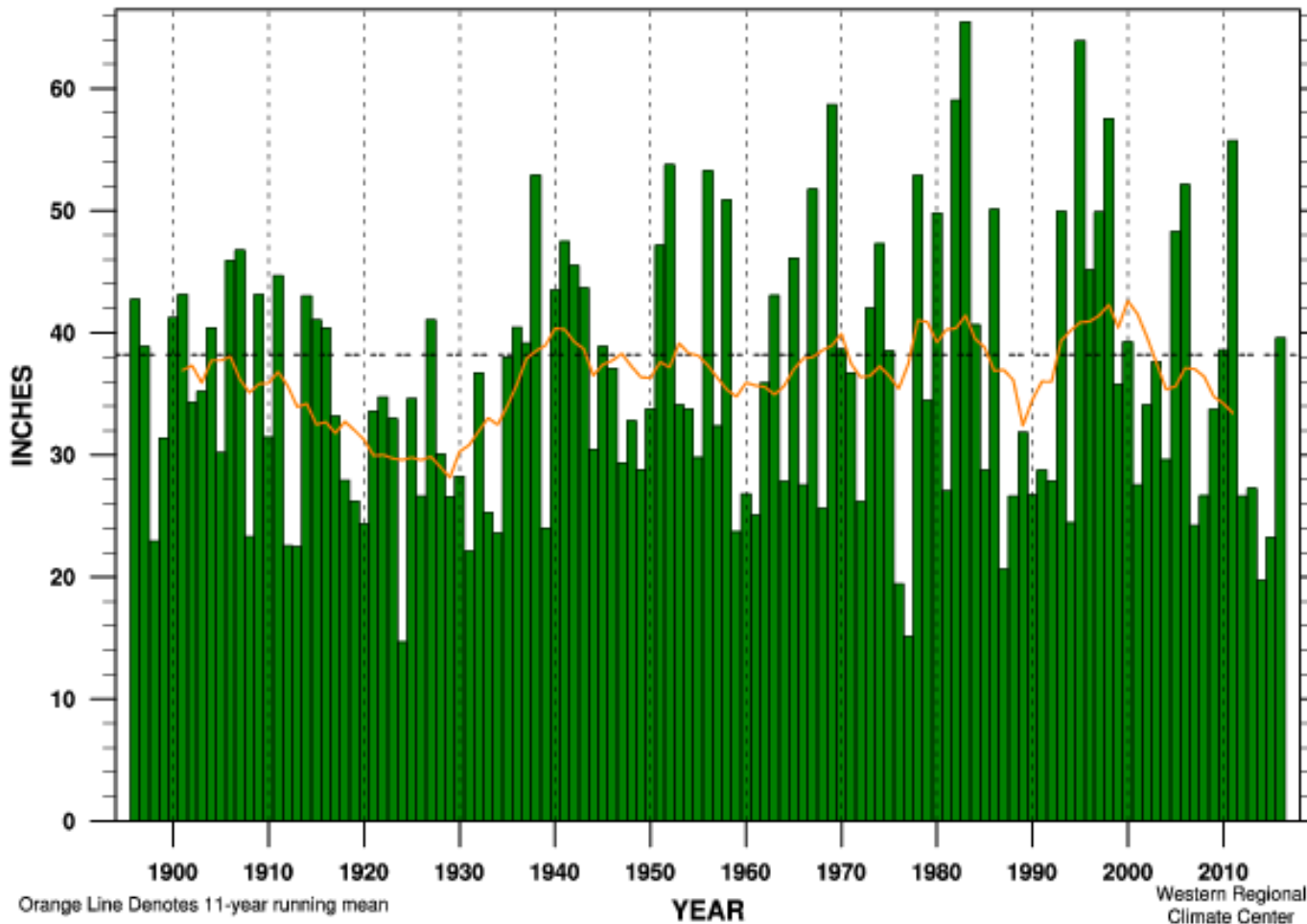
Sierra Nevada
Precipitation

Snow Season

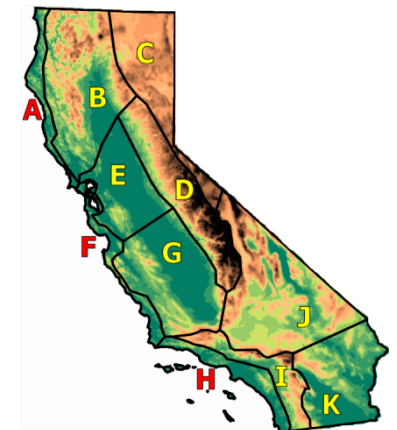
Oct-Jul

1895-96
thru
2015-16

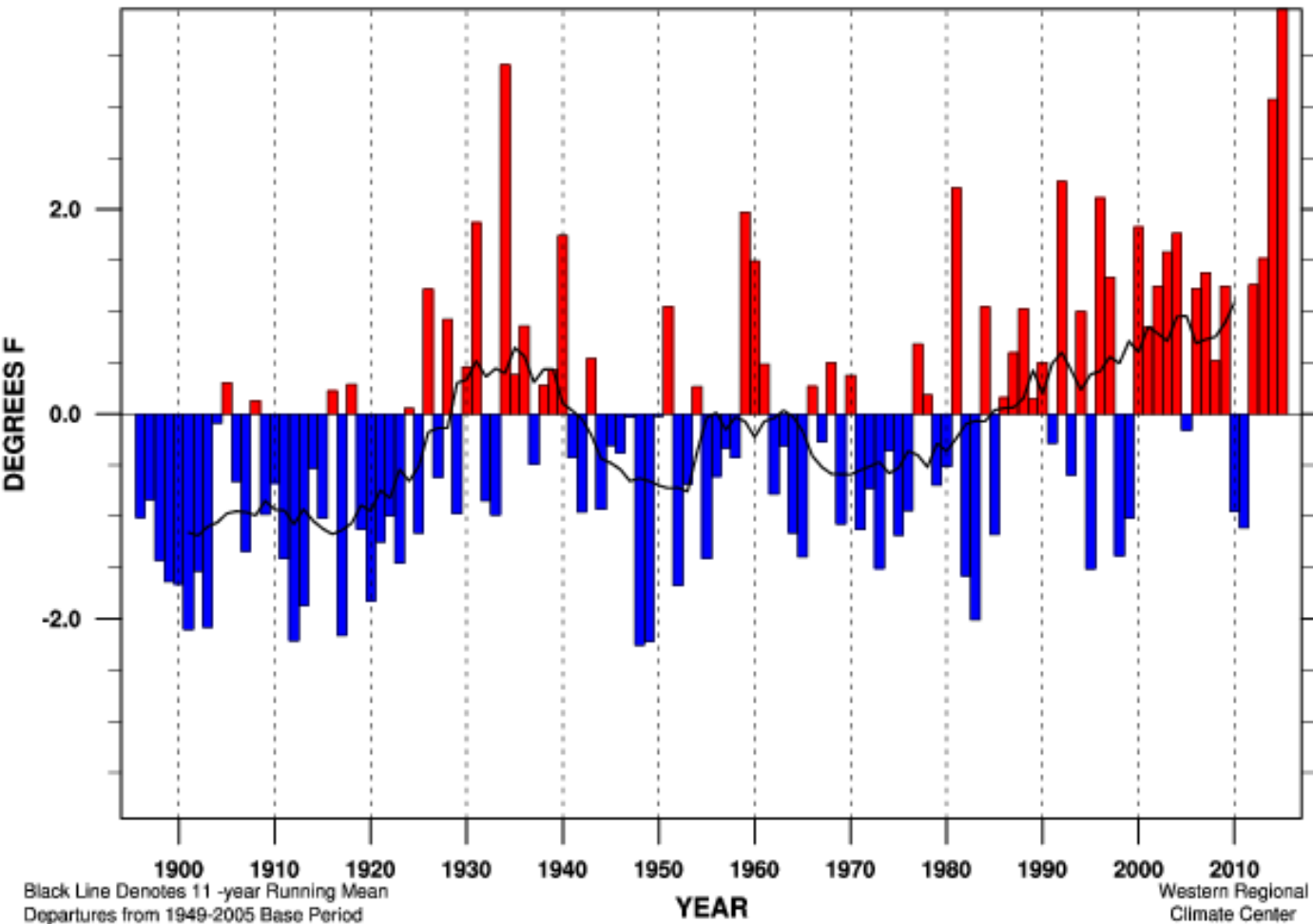
California
Climate Tracker



Linear Trend 1895-present	+ 2.71 ± 5.52 in.	(+ 7 ± 14%) per 100 yr	
Linear Trend 1949-present	- 4.64 ± 15.43 in.	(- 12 ± 40%) per 100 yr	
Linear Trend 1975-present	-10.35 ± 35.73 in.	(- 27 ± 93%) per 100 yr	
Wettest Year	65.48 in. (171%) in 1983	MEAN	38.19 in.
Driest Year	14.68 in. (38%) in 1924	STDEV	12.22 in.
Oct-Jul 2016	39.56 in. (103%)	RANK	79 of 121



Sierra Region Mean Temperature Departure Oct-Sep



Linear Trend 1895-present	+ 1.63 ± 0.59 °F/100yr
Linear Trend 1949-present	+ 2.75 ± 1.51 °F/100yr
Linear Trend 1975-present	+ 4.83 ± 3.48 °F/100yr
Warmest Year	53.0 °F (+ 4.0 °F) in 2015
Coldest Year	46.8 °F (- 2.3 °F) in 1948
Oct-Sep 2015	53.0 °F (+ 4.0 °F)

MEAN 49.0 °F
STDEV 1.15 °F
RANK 120 of 120

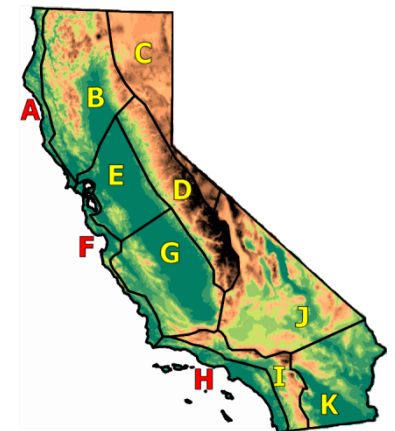
Sierra Nevada
Temperature

Water Year

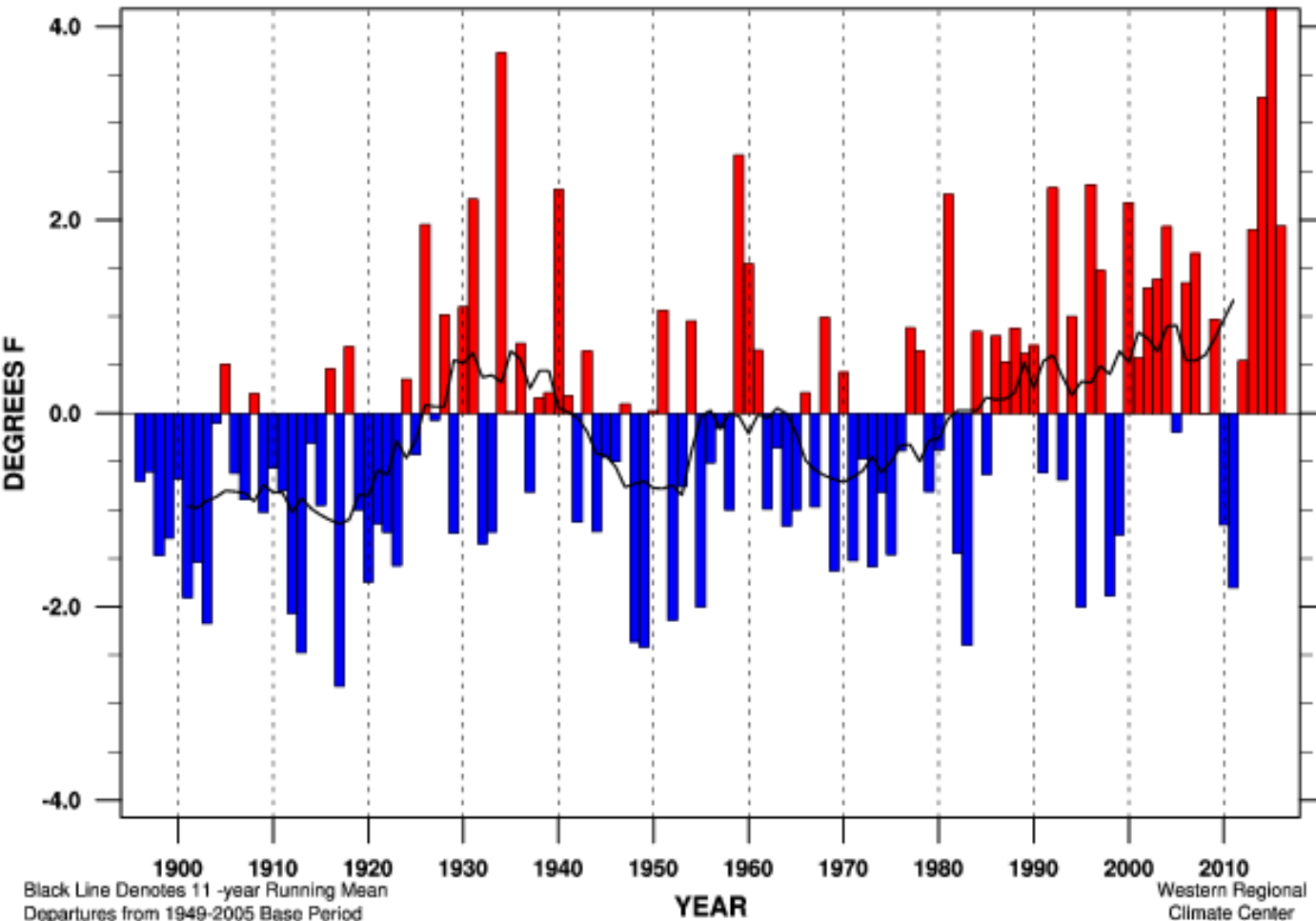
Oct-Sep

1895-96
thru
2014-15

California
Climate Tracker



Sierra Region Mean Temperature Departure Oct-Jul



Linear Trend 1895-present	+ 1.47 ± 0.67 °F/100yr
Linear Trend 1949-present	+ 2.73 ± 1.70 °F/100yr
Linear Trend 1975-present	+ 4.12 ± 3.79 °F/100yr
Warmest Year	50.4 °F (+ 4.2 °F) in 2015
Coldest Year	43.4 °F (- 2.8 °F) in 1917
Oct-Jul	2016
	48.2 °F (+ 1.9 °F)

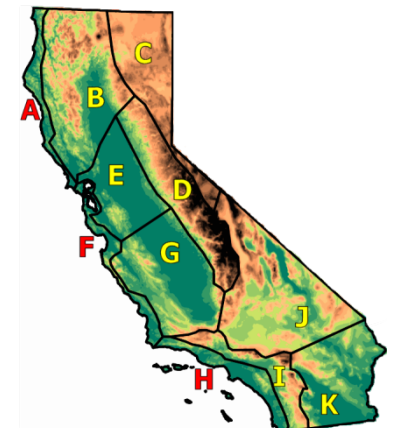
MEAN 46.2 °F
STDEV 1.31 °F
RANK 110 of 121

**Sierra Nevada
Temperature**

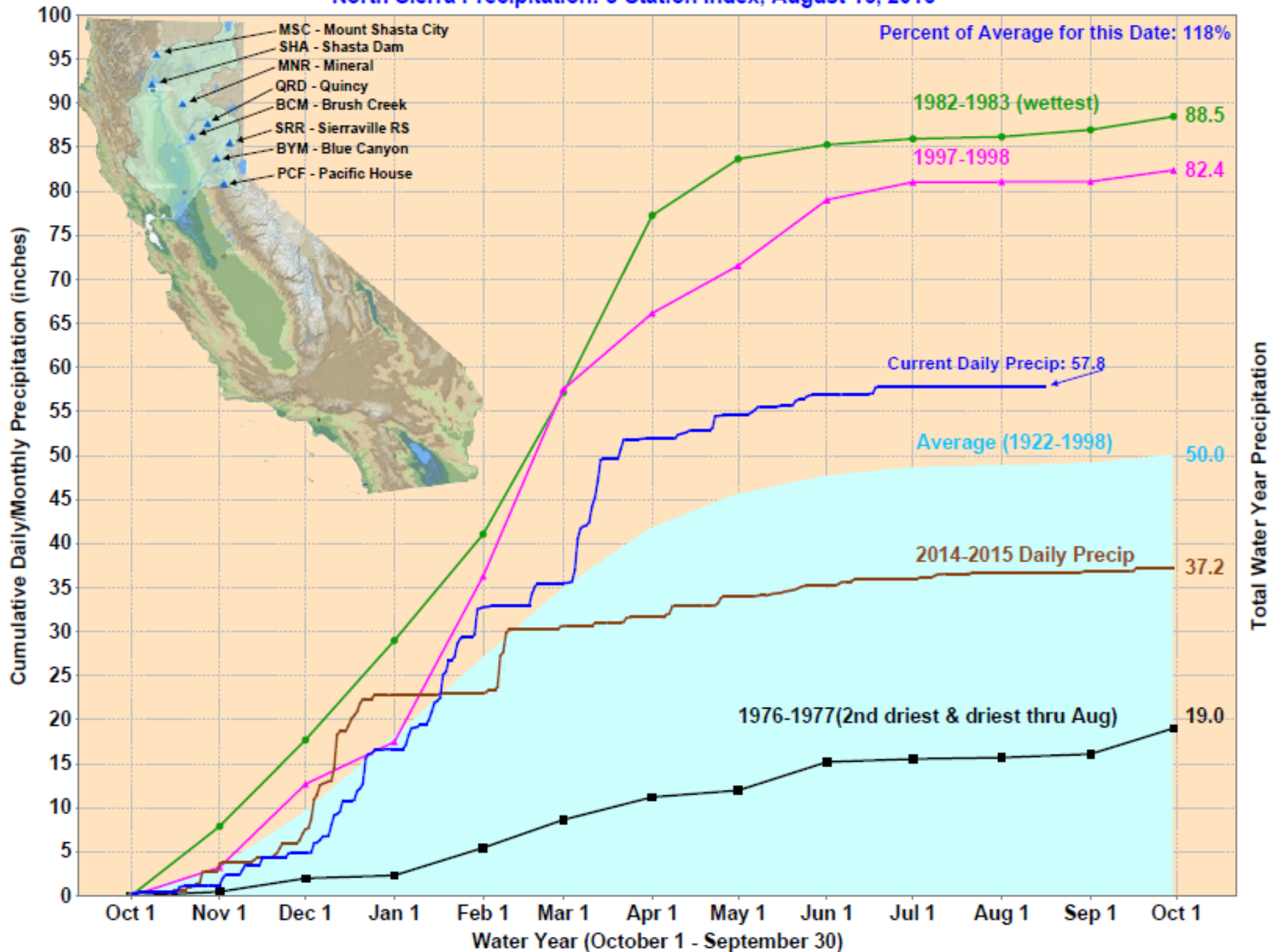
Oct-Jul

**1895-96
thru
2015-16**

**California
Climate Tracker**

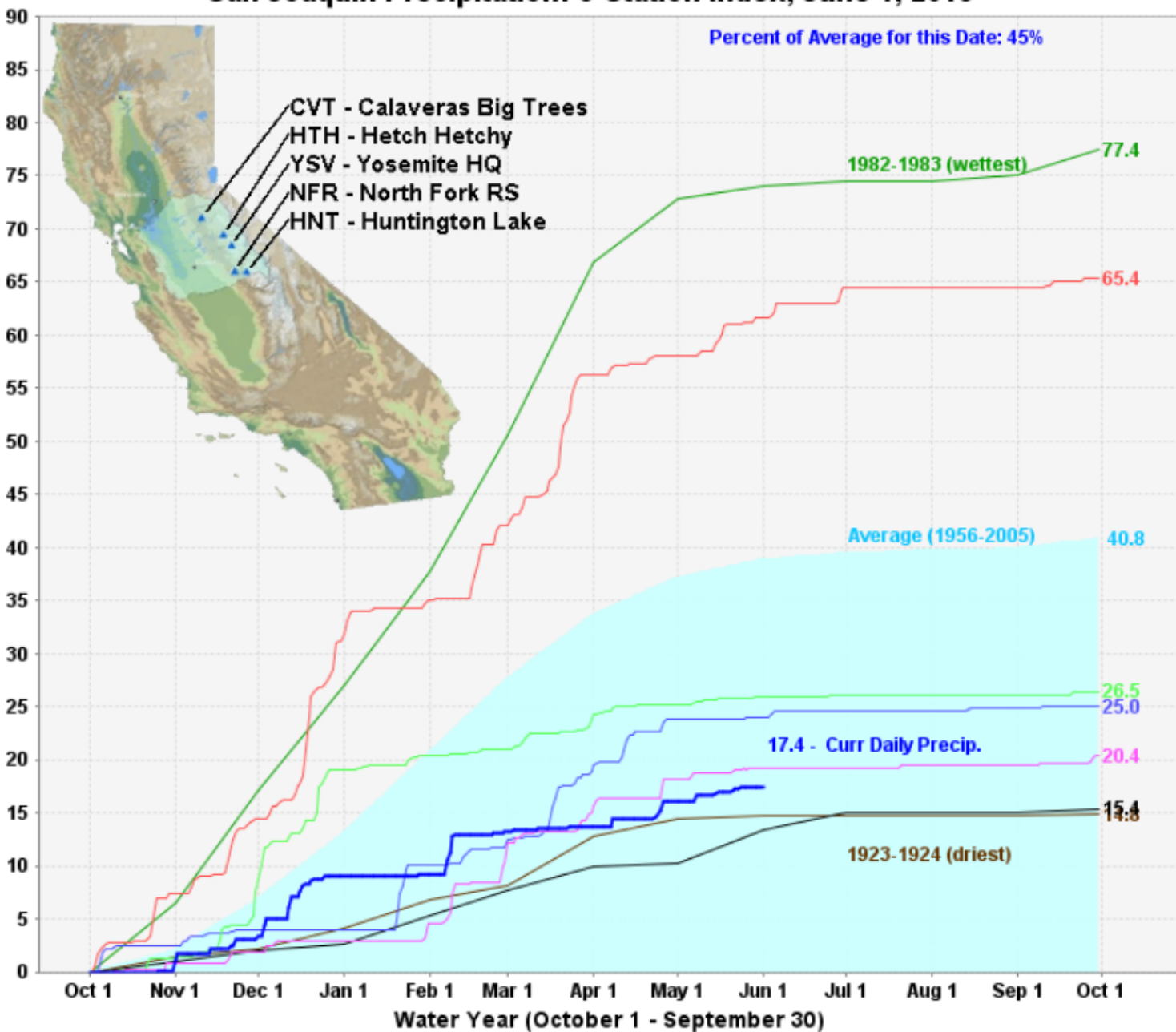


North Sierra Precipitation: 8-Station Index, August 16, 2016



San Joaquin Precipitation: 5-Station Index, June 1, 2015

Cumulative Daily/Monthly Precipitation (inches)



5-Station Index
Precipitation

Wettest (1982-83)

2010-11

2012-13

2011-12

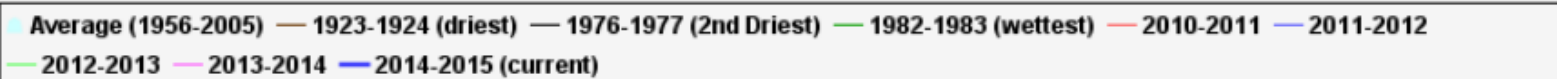
2013-14

2014-15

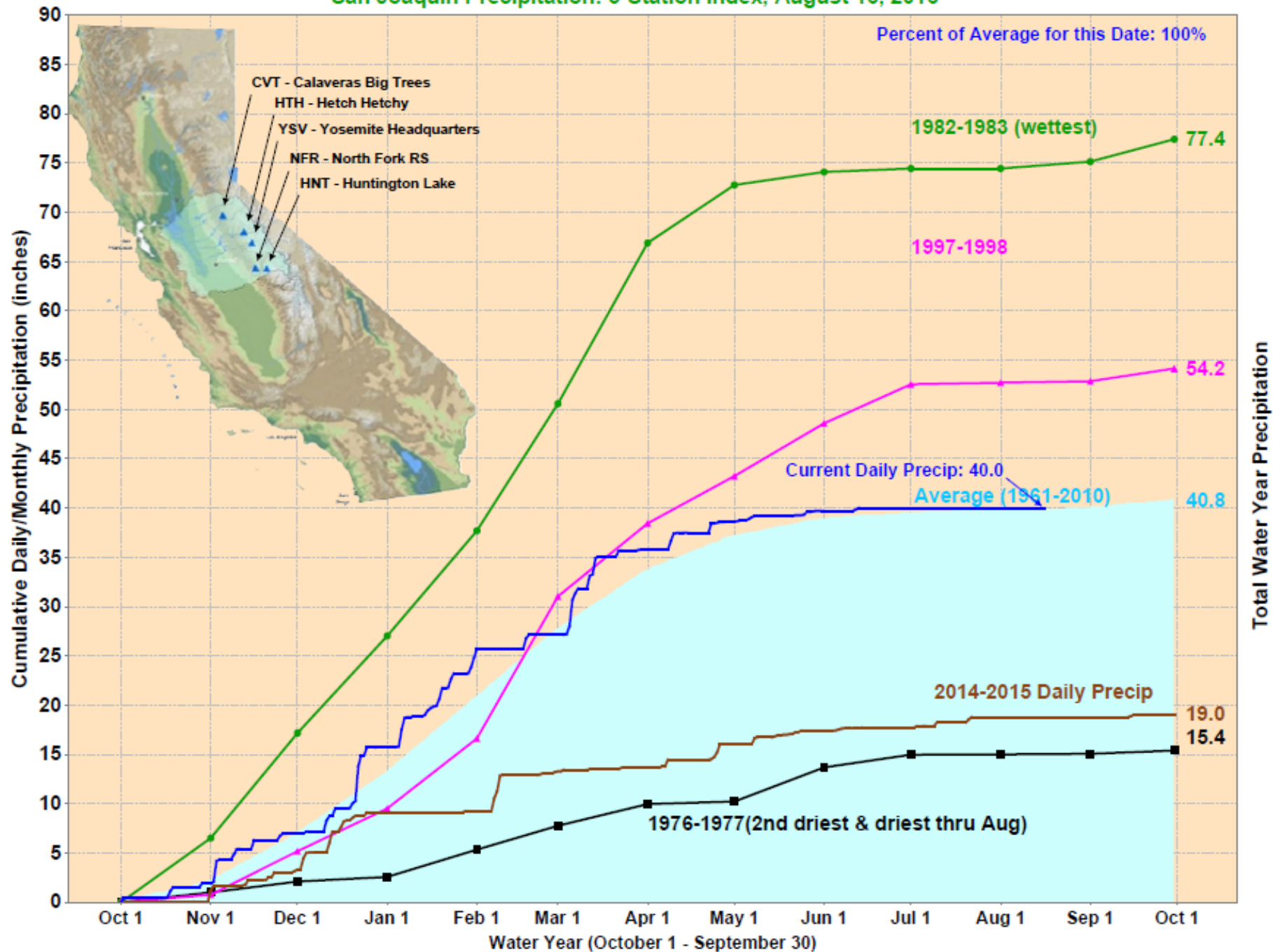
Two driest years,
(1976-77, 1923-24)

CA - DWR

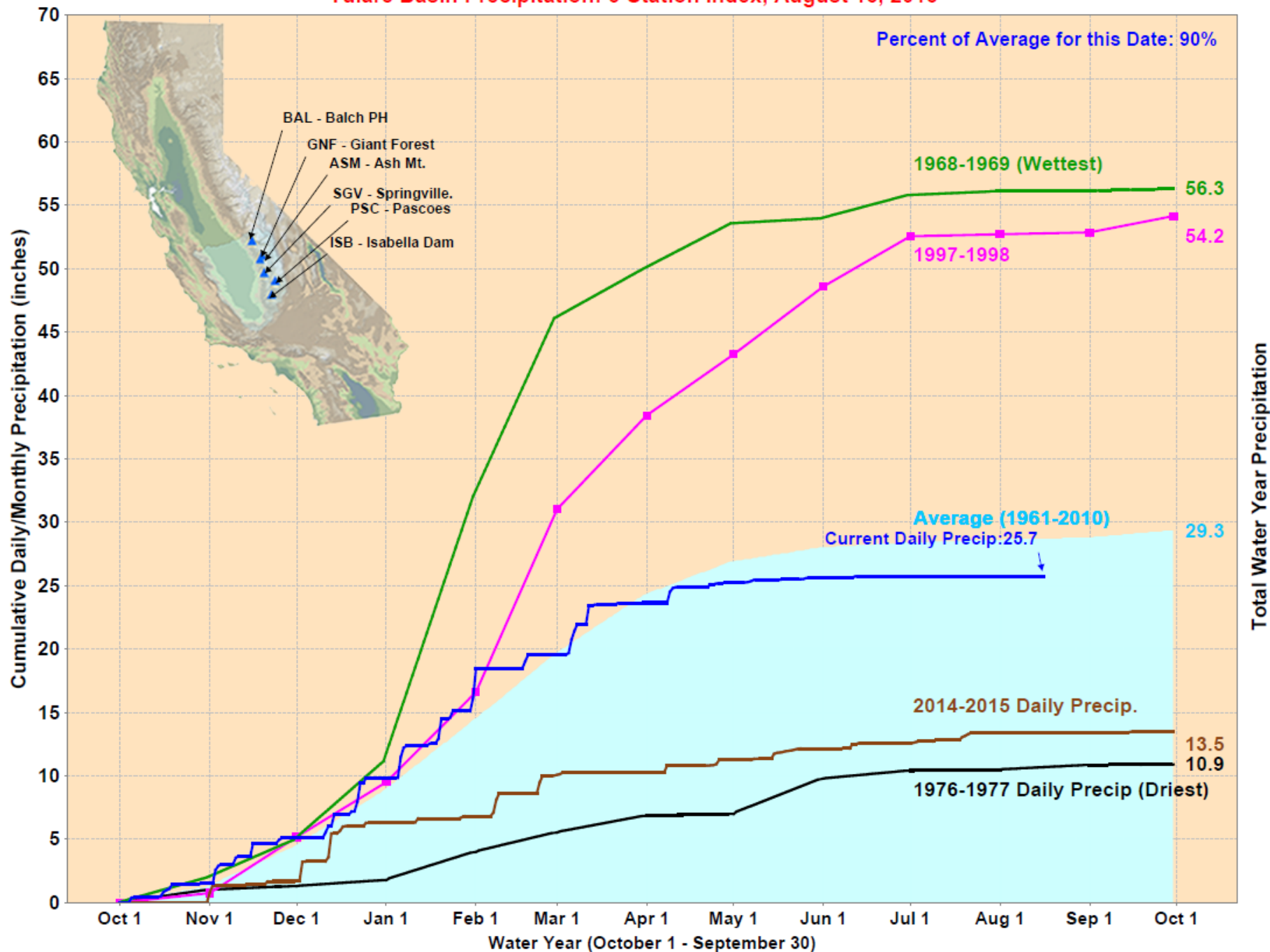
Total Water Year Precipitation



San Joaquin Precipitation: 5-Station Index, August 16, 2016

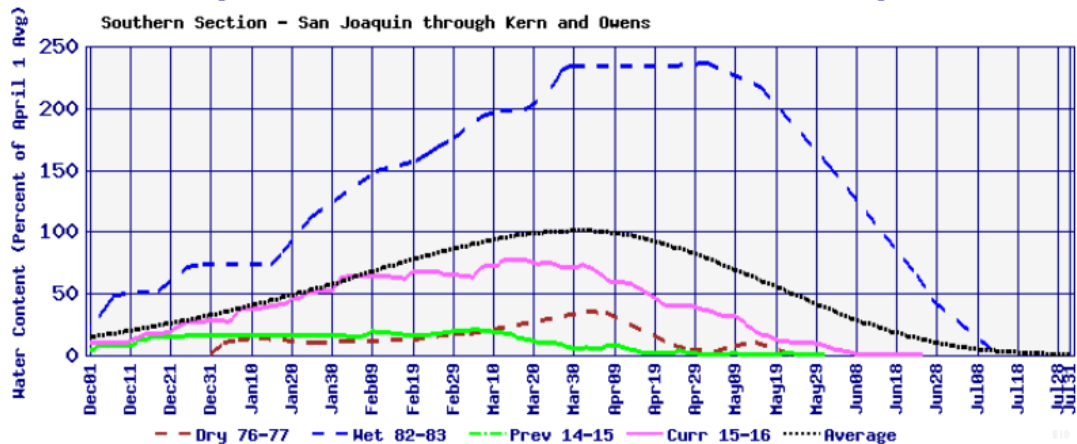
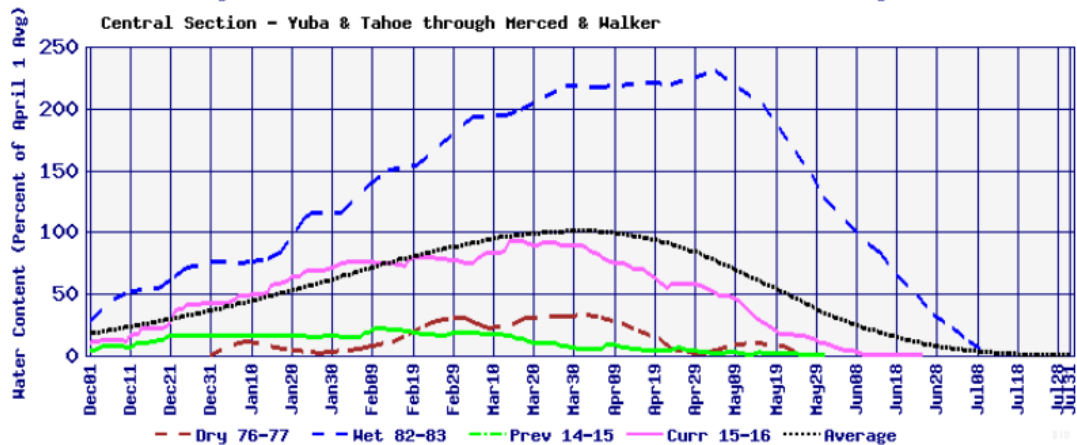
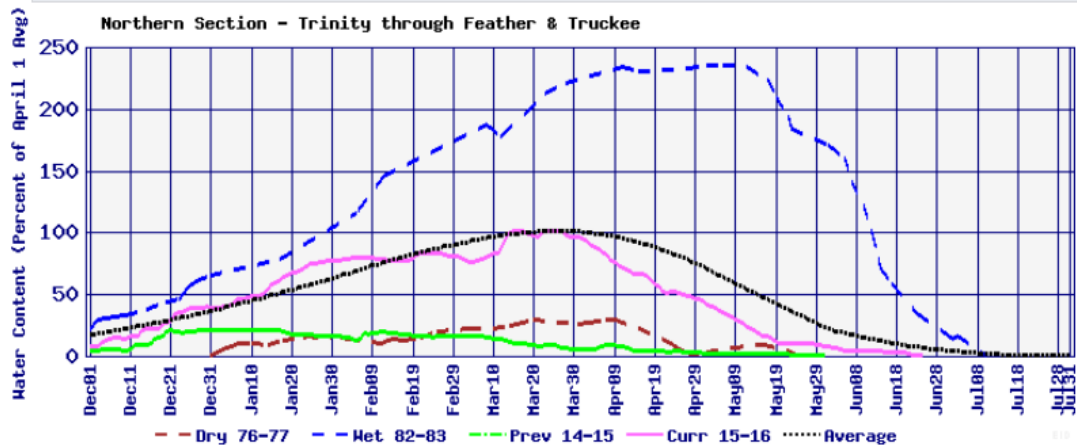


Tulare Basin Precipitation: 6-Station Index, August 16, 2016



California Snow Water Content

PERCENT OF APRIL 1 AVERAGE, JULY 06, 2016



Winter Season
Snow Water
Content

Northern
Sierra

1982-83 wettest

Average

2014-15

Central
Sierra

2015-16

1976-77 driest

Southern
Sierra

Thru 06 July 2016
Cal DWR

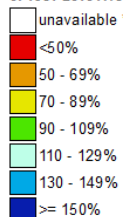
1 Oct 2015 - 1 Mar 2016

Precipitation

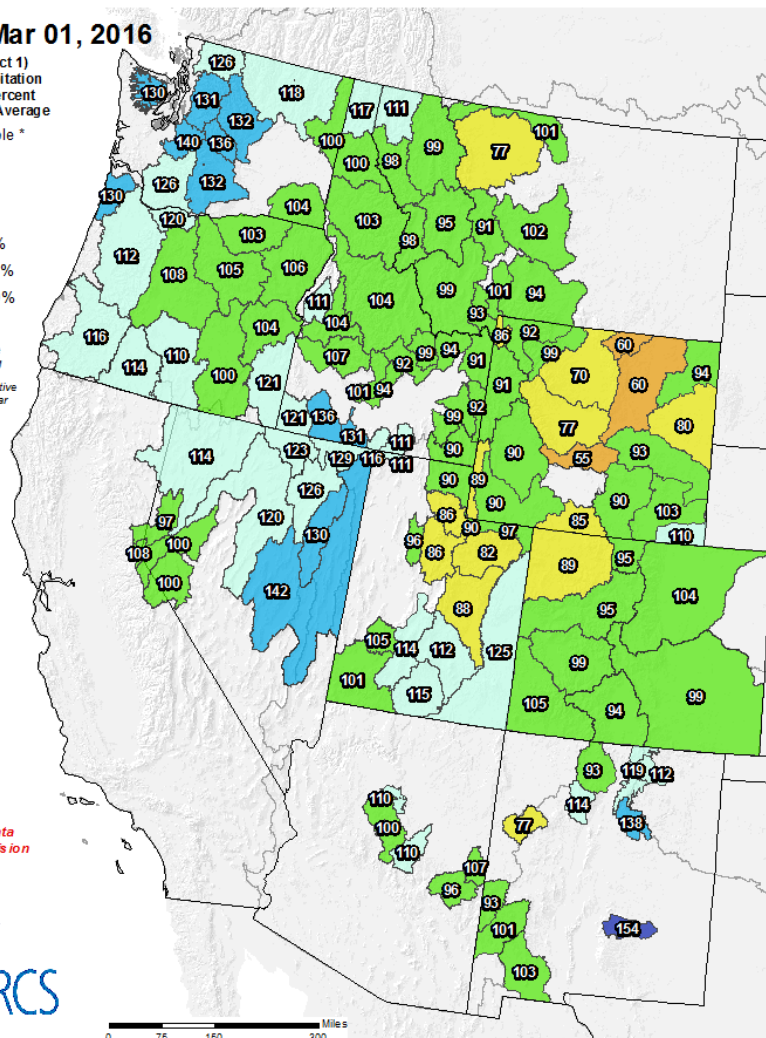
Westwide SNOTEL Water Year (Oct 1) to Date Precipitation % of Normal

Mar 01, 2016

Water Year (Oct 1)
to Date Precipitation
Basin-wide Percent
of 1981-2010 Average



* Data unavailable
at time of posting
or measurement
is not representative
at this time of year



Provisional data
subject to revision



The water year to date precipitation percent of normal represents the accumulated precipitation found at selected SNOTEL sites in or near the basin compared to the average value for those sites on this day. Data based on the first reading of the day (typically 00:00).

Prepared by:
USDA/NRCS National Water and Climate Center
Portland, Oregon
<http://www.wcc.nrcs.usda.gov>

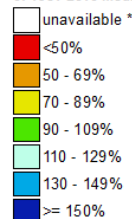
2 Mar 2016

Snowpack

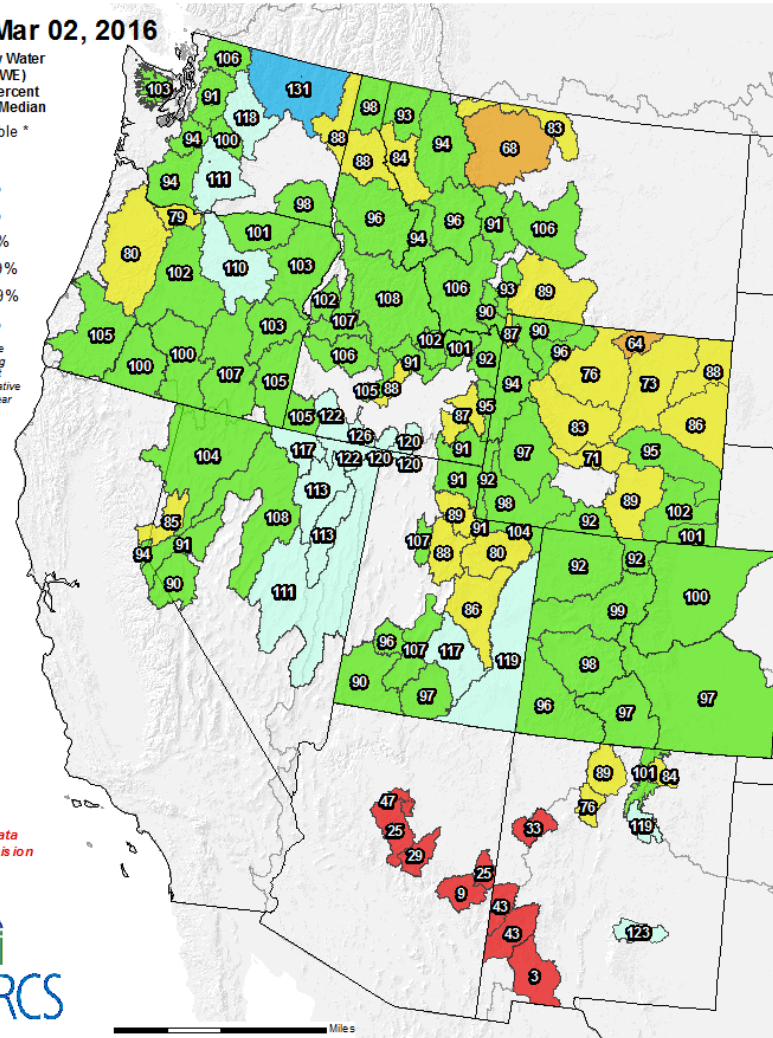
Westwide SNOTEL Current Snow Water Equivalent (SWE) % of Normal

Mar 02, 2016

Current Snow Water
Equivalent (SWE)
Basin-wide Percent
of 1981-2010 Median



* Data unavailable
at time of posting
or measurement
is not representative
at this time of year



Provisional data
subject to revision

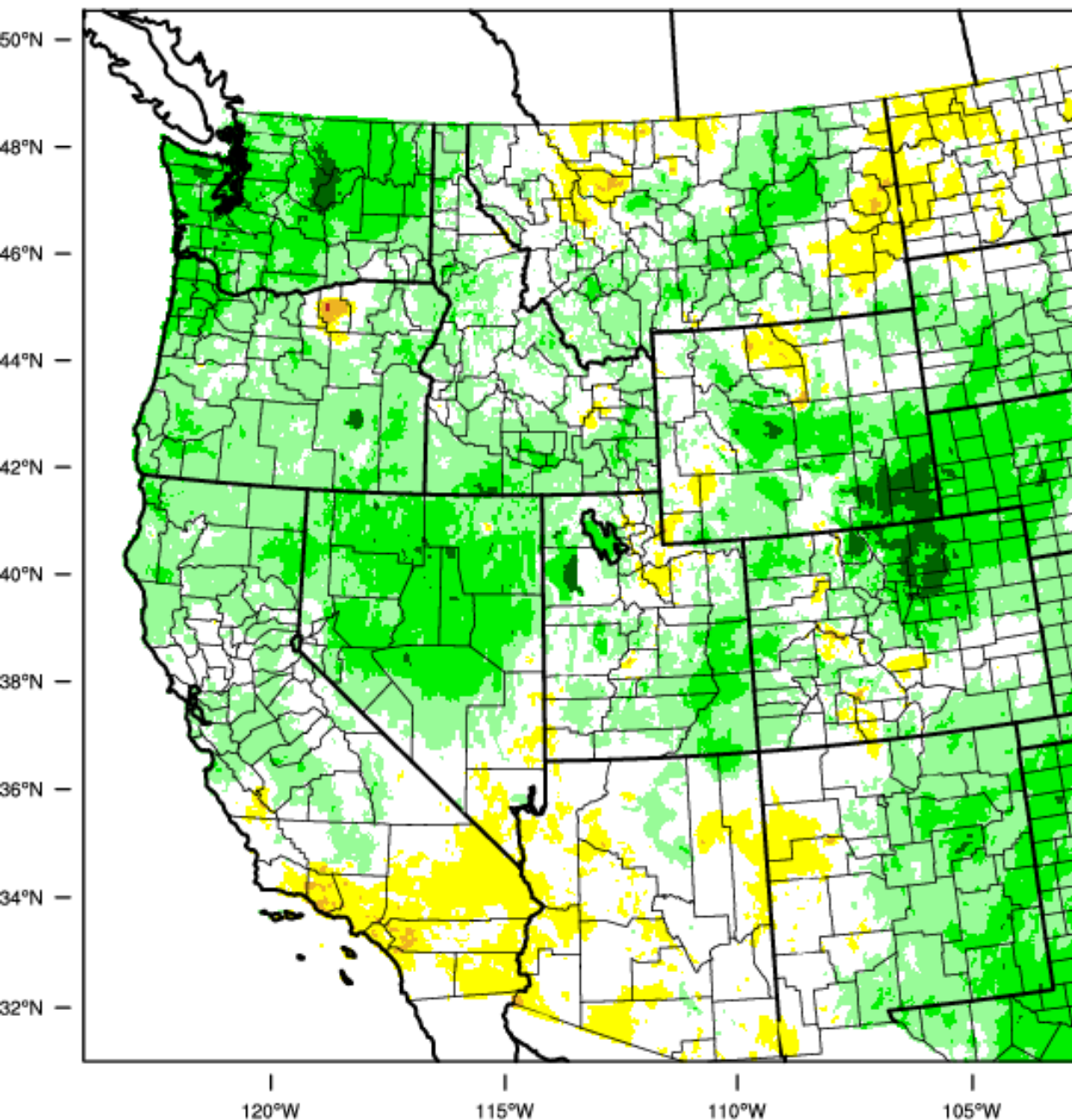


The snow water equivalent percent of normal represents the current snow water equivalent found at selected SNOTEL sites in or near the basin compared to the average value for those sites on this day. Data based on the first reading of the day (typically 00:00).

Prepared by:
USDA/NRCS National Water and Climate Center
Portland, Oregon
<http://www.wcc.nrcs.usda.gov>

Western United States - Precipitation

October-March 2016 Percentile



RECORD
WETTEST

MUCH
ABOVE
NORMAL
Top 10%

ABOVE
NORMAL
Top 33%

NEAR
NORMAL

BELOW
NORMAL
Bottom 33%

MUCH
BELOW
NORMAL
Bottom 10%

RECORD
DRIEST

Rankings (1895-2010)

Western US
Precipitation
Percentiles

Oct 2015
thru
Mar 2016

Reference
Period
120 Years
1895-2015

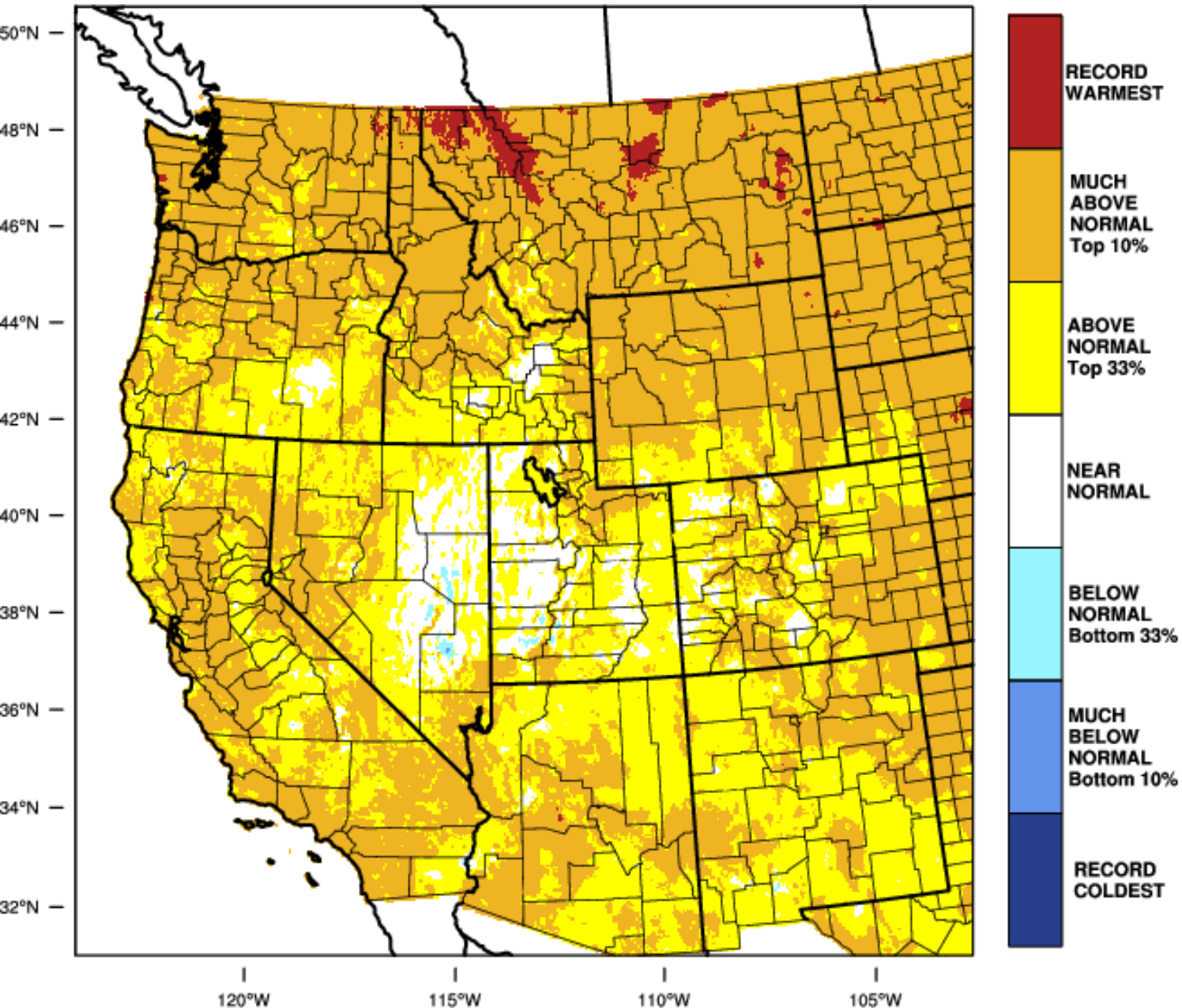
WestWide
Drought
Tracker

Updated
Monthly

WRCC

Western United States - Mean Temperature

October-March 2016 Percentile



**Western US
Temperature
Percentiles**

**Oct 2015
thru
Mar 2016**

**Reference
Period
120 Years
1895-2015**

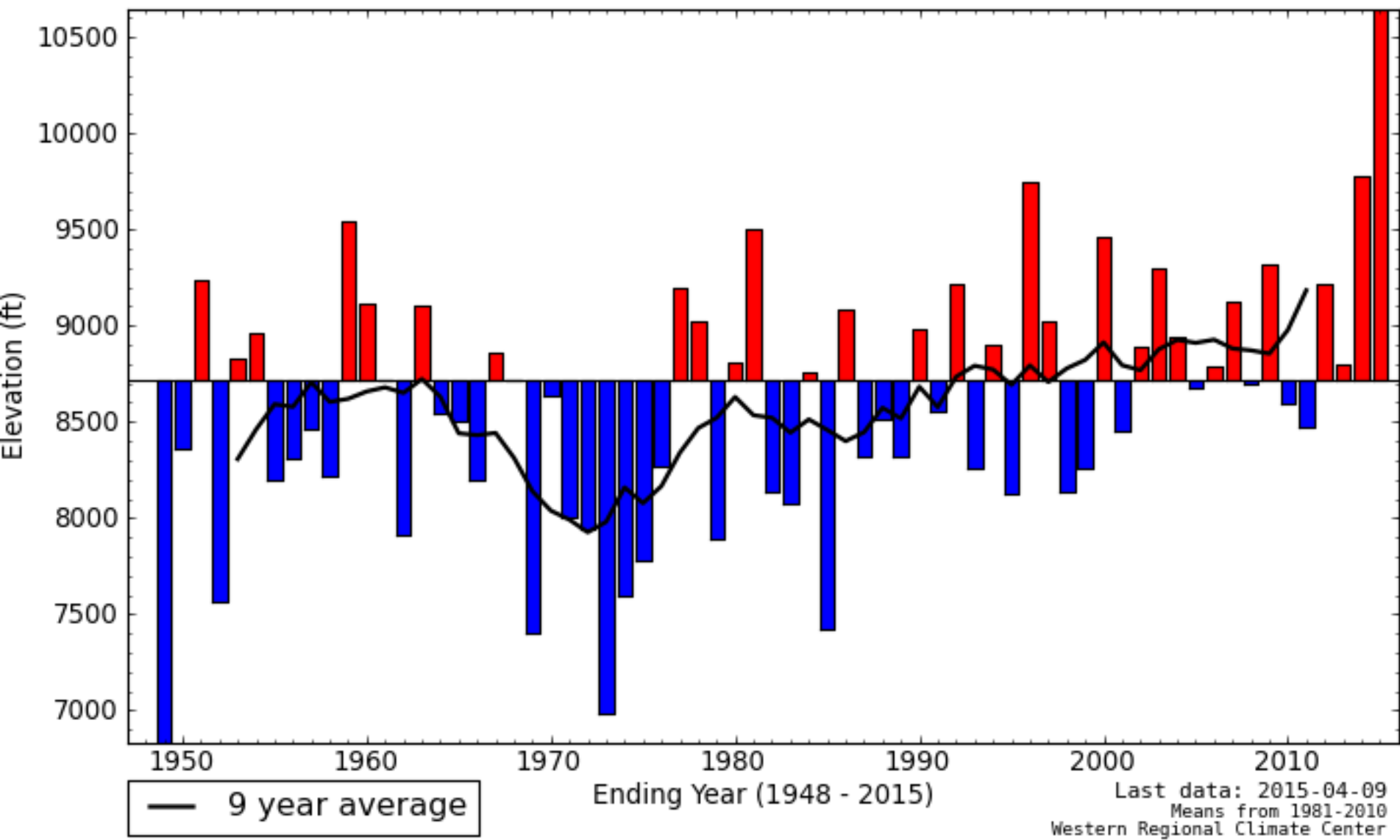
**WestWide
Drought
Tracker**

**Updated
Monthly**

WRCC

Oct-Mar Freezing Level Over Lake Tahoe. 1948-49 thru 2014-15

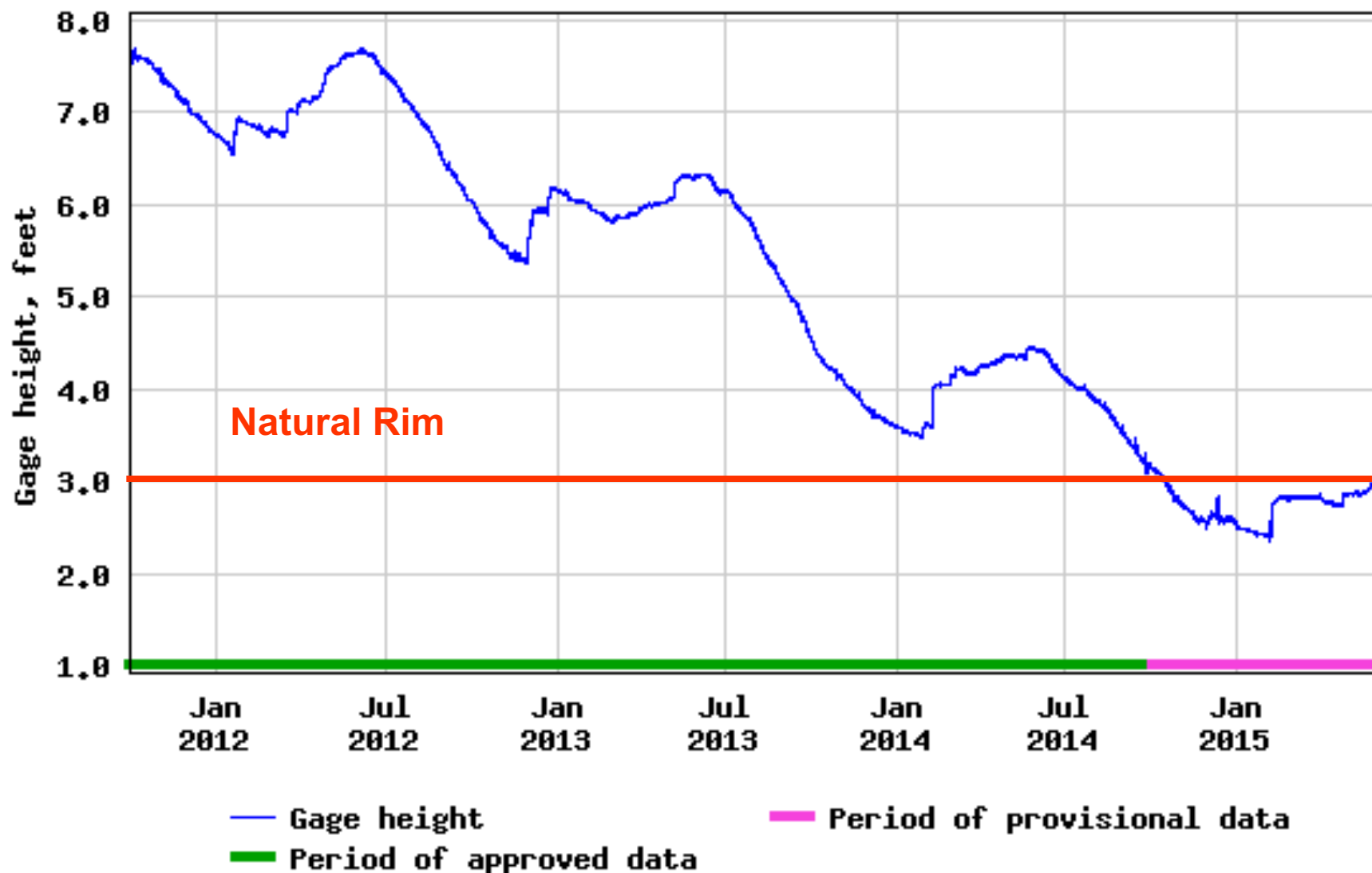
0°C Level at 39.06°N, 120.02°W - 6 Months Ending in March



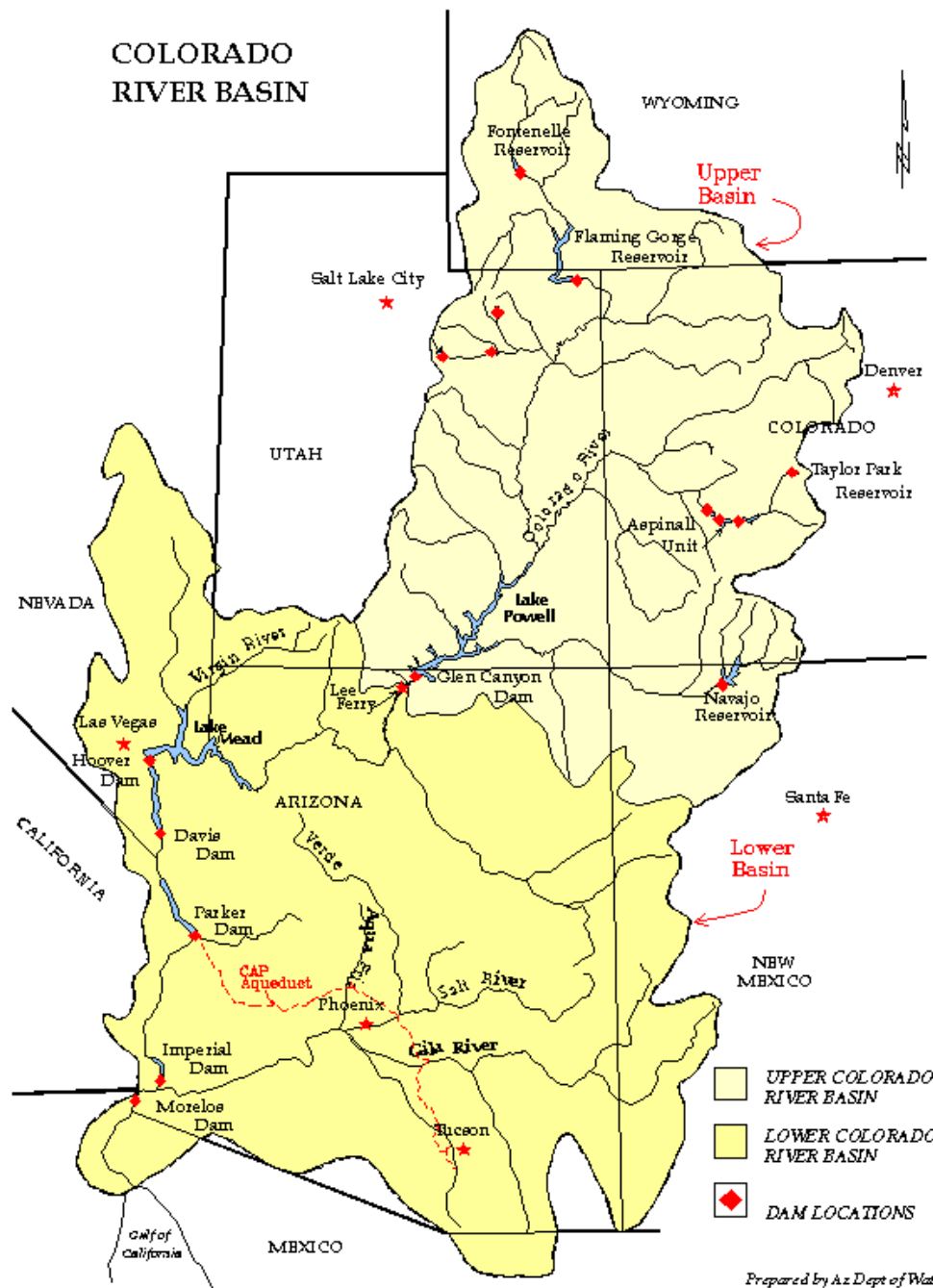
Elevation of Lake Tahoe at Tahoe City 2011 Oct 01 - 2016 Aug 22



USGS 10337000 LAKE TAHOE A TAHOE CITY CA

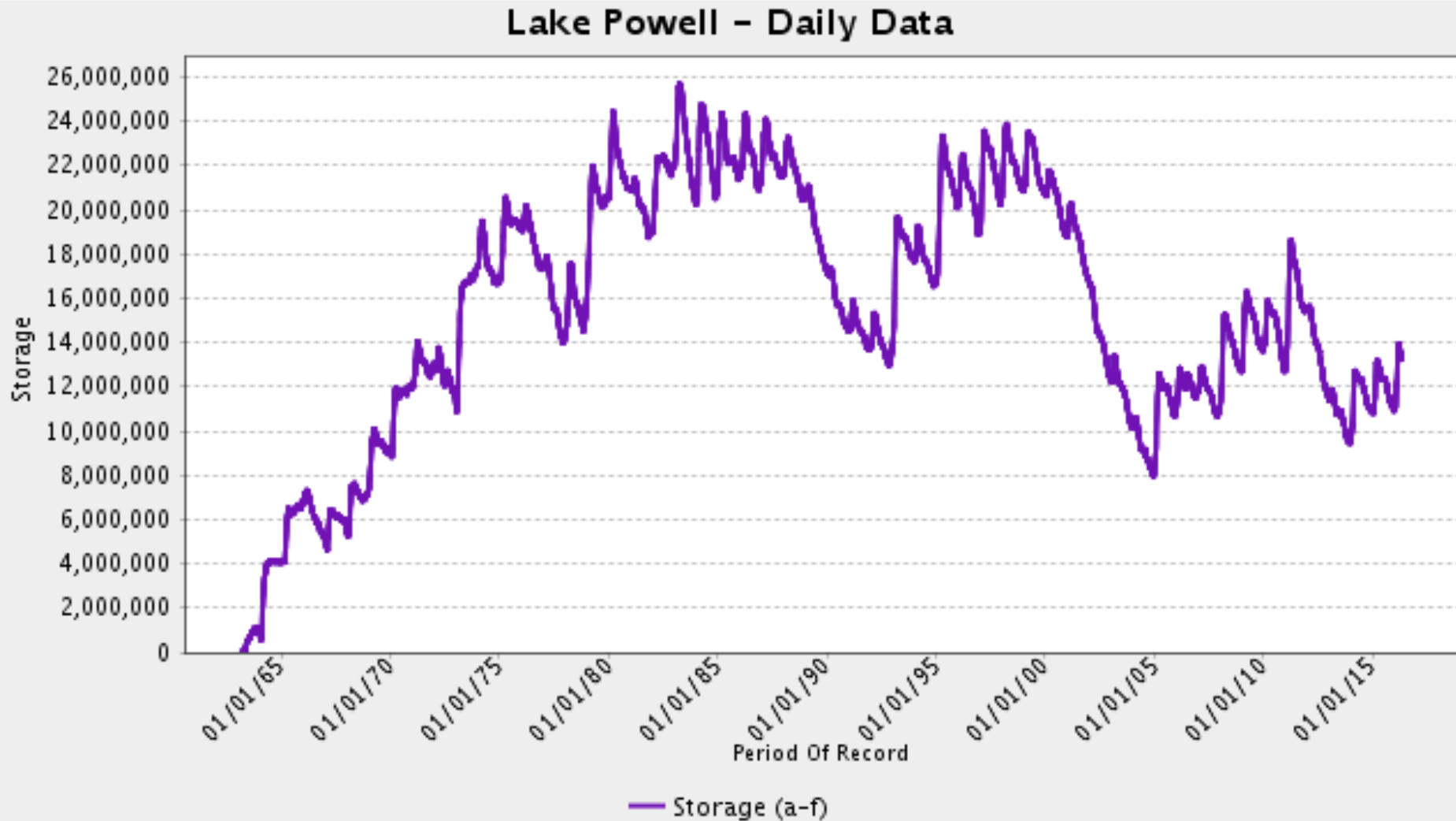


COLORADO RIVER BASIN



Prepared by Az Dept of Water
Resources, Colorado River Mgmt
Phyllis Andrews June 12, 1997

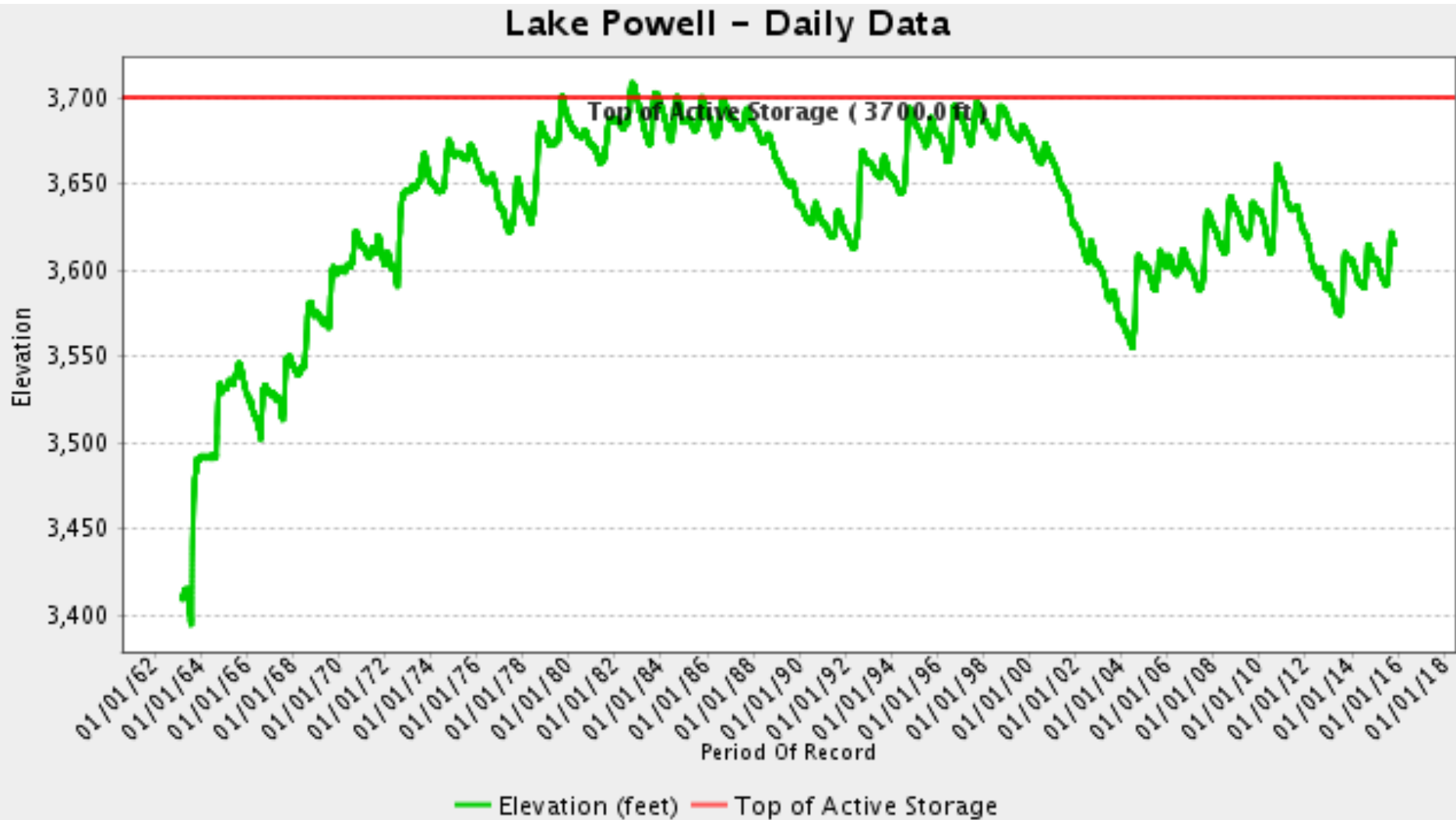
Lake Powell Storage Through Aug 23, 2016



Currently 55 % full (capacity 24.17 MAF)

Minimum: 33 % full on April 8, 2005

Lake Powell Elevation Through Aug 23, 2016



Water level on , 2016 was 3614.82 ft, - 85 ft below full.

Minimum level on April 8, 2005 was 3555 ft, -145 ft below full.

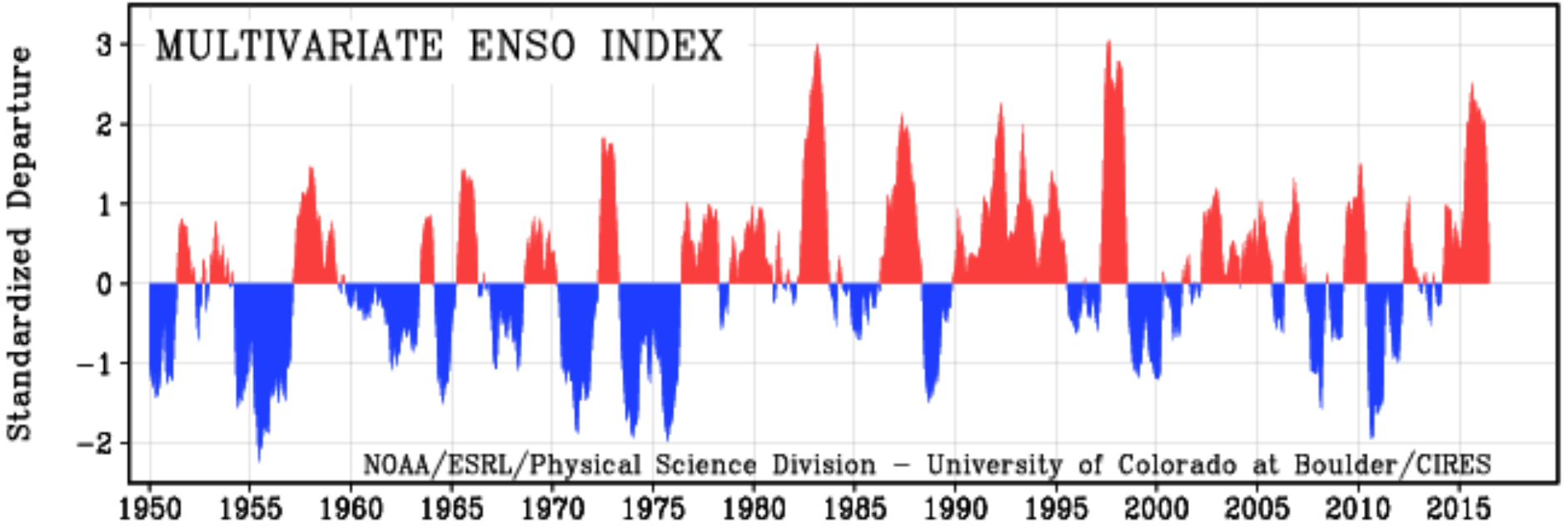
Source: www.usbr.gov/uc/water/index.html



Lake Mead. Kelly Redmond 20150220

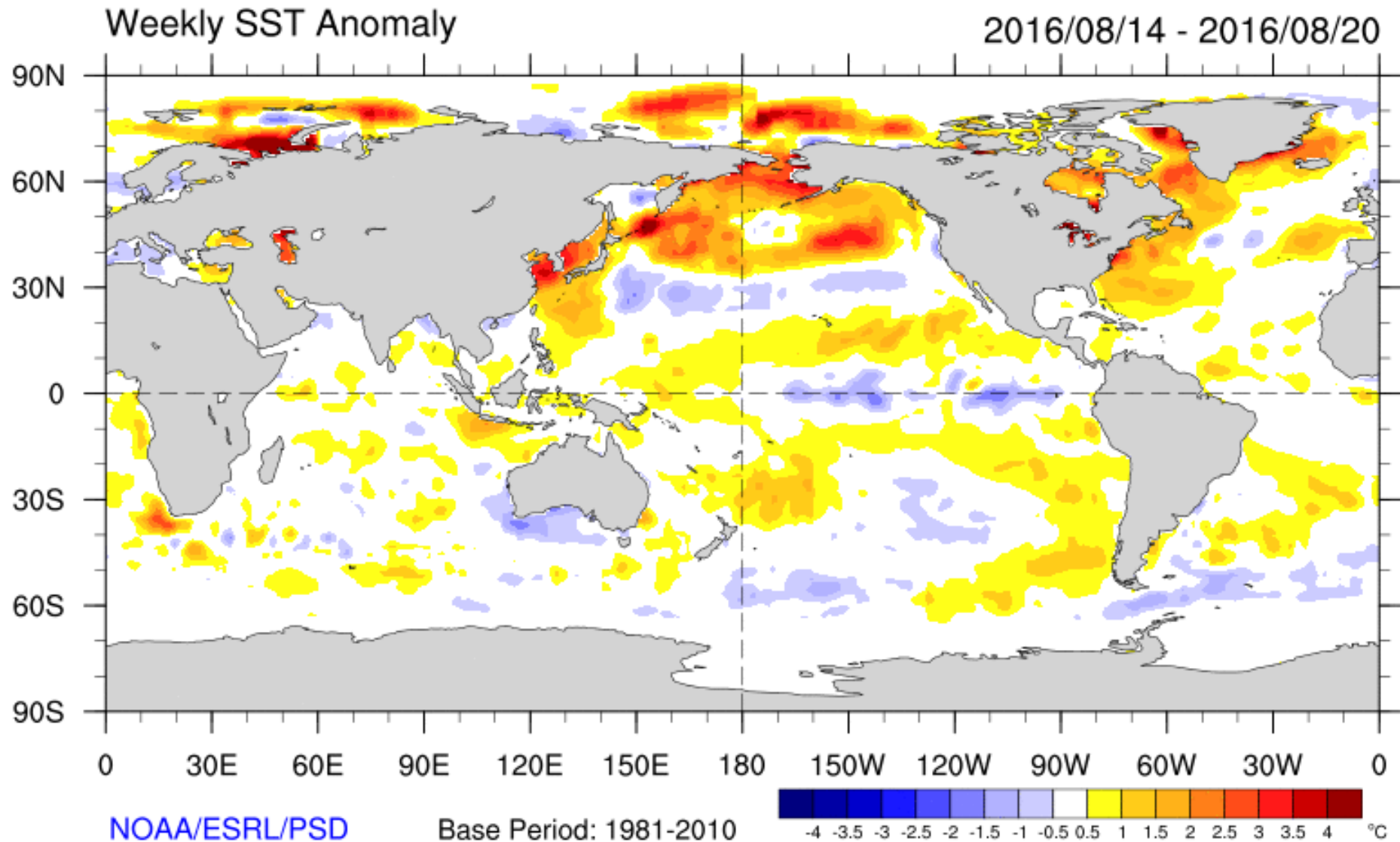


Through Aug 2016



NOAA ESRL (“CDC”), Wolter and Timlin

Ocean Departures from Average Temperature (C) 14 - 20 Aug 2016



Recent Evolution of Equatorial Pacific SST Departures

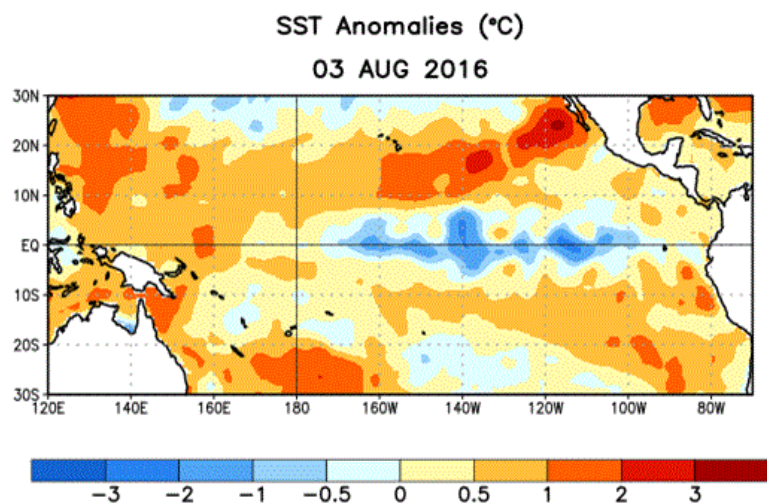


Figure 1. Average sea surface temperature (SST) anomalies (°C) for the week centered on 3 August 2016. Anomalies are computed with respect to the 1981-2010 base period weekly means.

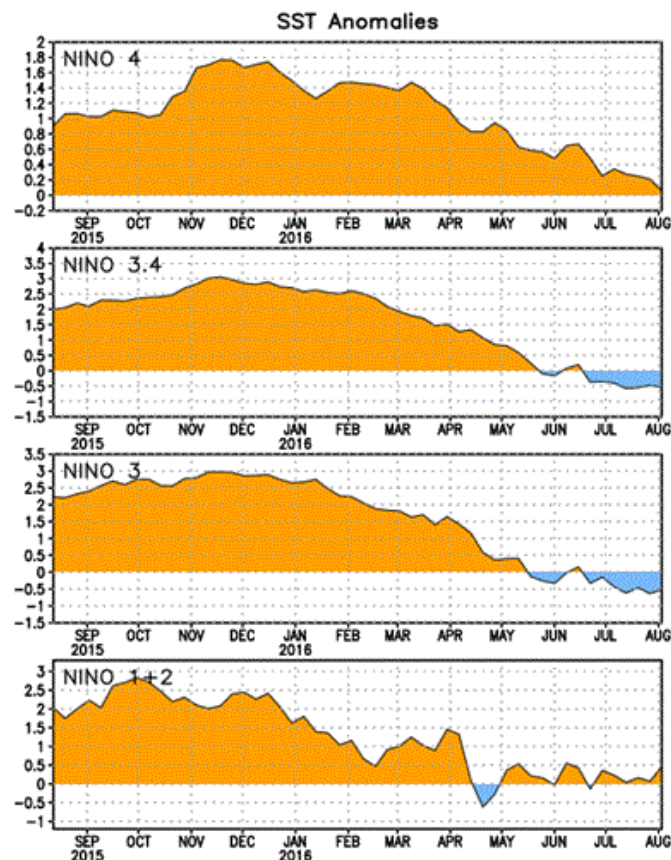
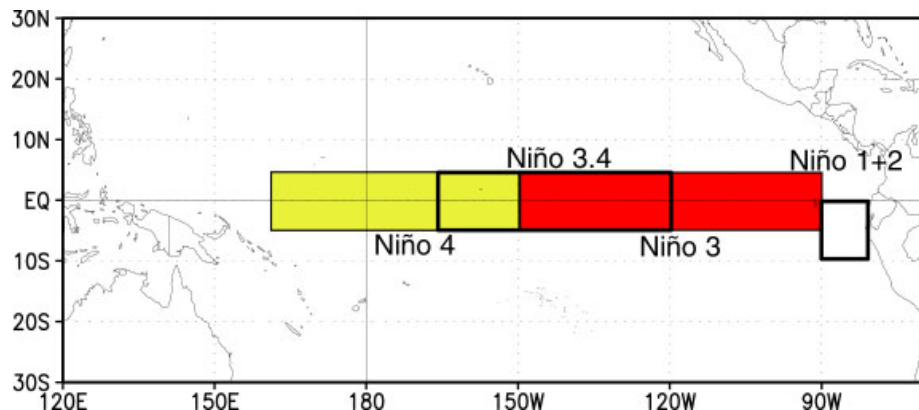


Figure 2. Time series of area-averaged sea surface temperature (SST) anomalies (°C) in the Niño regions [Niño-1+2 (0°-10°S, 90°W-80°W), Niño-3 (5°N-5°S, 150°W-90°W), Niño-3.4 (5°N-5°S, 170°W-120°W), Niño-4 (5°N-5°S, 150°W-160°E)]. SST anomalies are departures from the 1981-2010 base period weekly means.

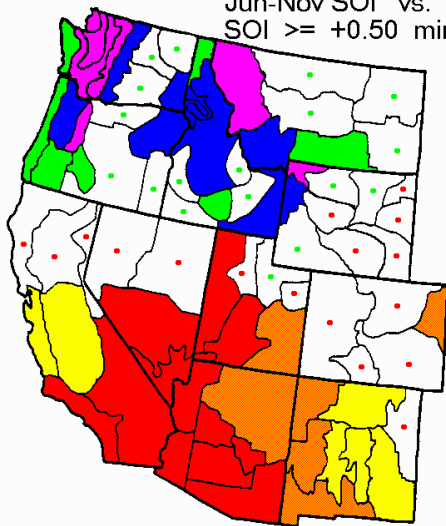


Updated through 2015 Aug 1 - 6

Climate Prediction Center

Split Samples:

Jun-Nov SOI vs. Oct-Mar Precip
SOI $\geq +0.50$ minus SOI ≤ -0.50



- $t > 0, p \leq 0.001$
- $t > 0, p \leq 0.01$
- $t > 0, p \leq 0.05$
- $t > 0, p > 0.05$
- $t < 0, p > 0.05$
- $t < 0, p \leq 0.05$
- $t < 0, p \leq 0.01$
- $t < 0, p \leq 0.001$

Updated from Redmond and Koch (1991). Winters of 1933/34 - 1994/95.
Reddish: Composite El Nino winters are wet, La Nina winters are dry.
Bluish/greenish: Composite El Nino winters are dry, La Nina winters are wet.

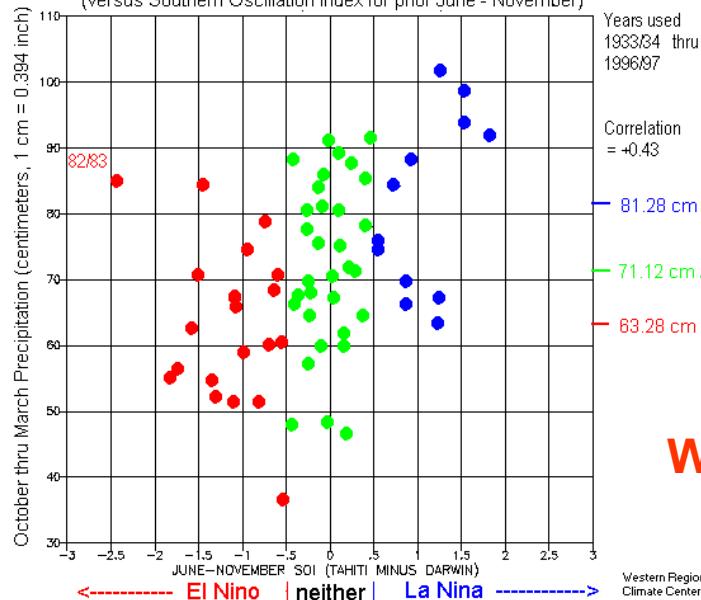
Redmond, K.T., and R.W. Koch, 1991. Surface climate and streamflow variability in the western United States and their relationship to large-scale circulation indices. Water Resources Research, 27(9), 2381-2399.

Redmond & Koch, 1991, updated.

ENSO

Washington statewide October thru March Precipitation

(versus Southern Oscillation Index for prior June - November)

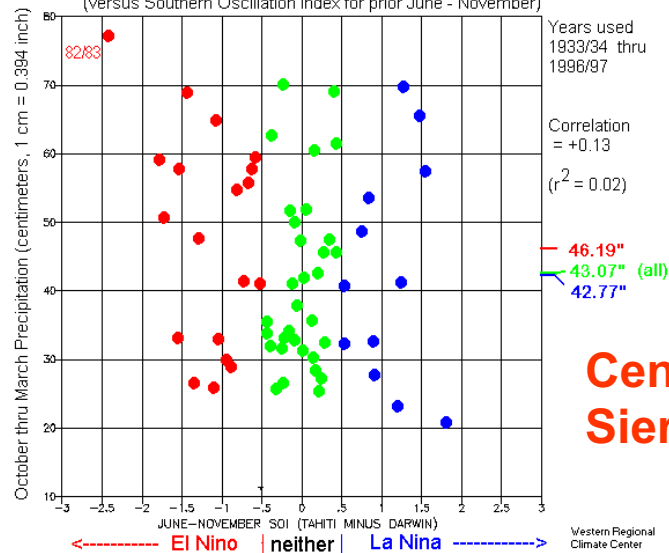


Redmond & Koch, 1991, updated.

Washington

California 8-Station Index October thru March Precipitation

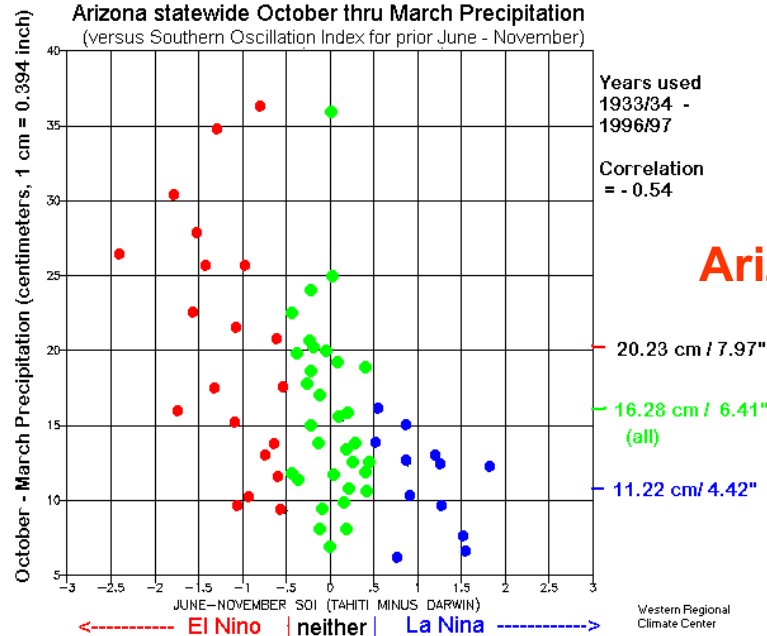
(versus Southern Oscillation Index for prior June - November)



Central Sierra

Arizona statewide October thru March Precipitation

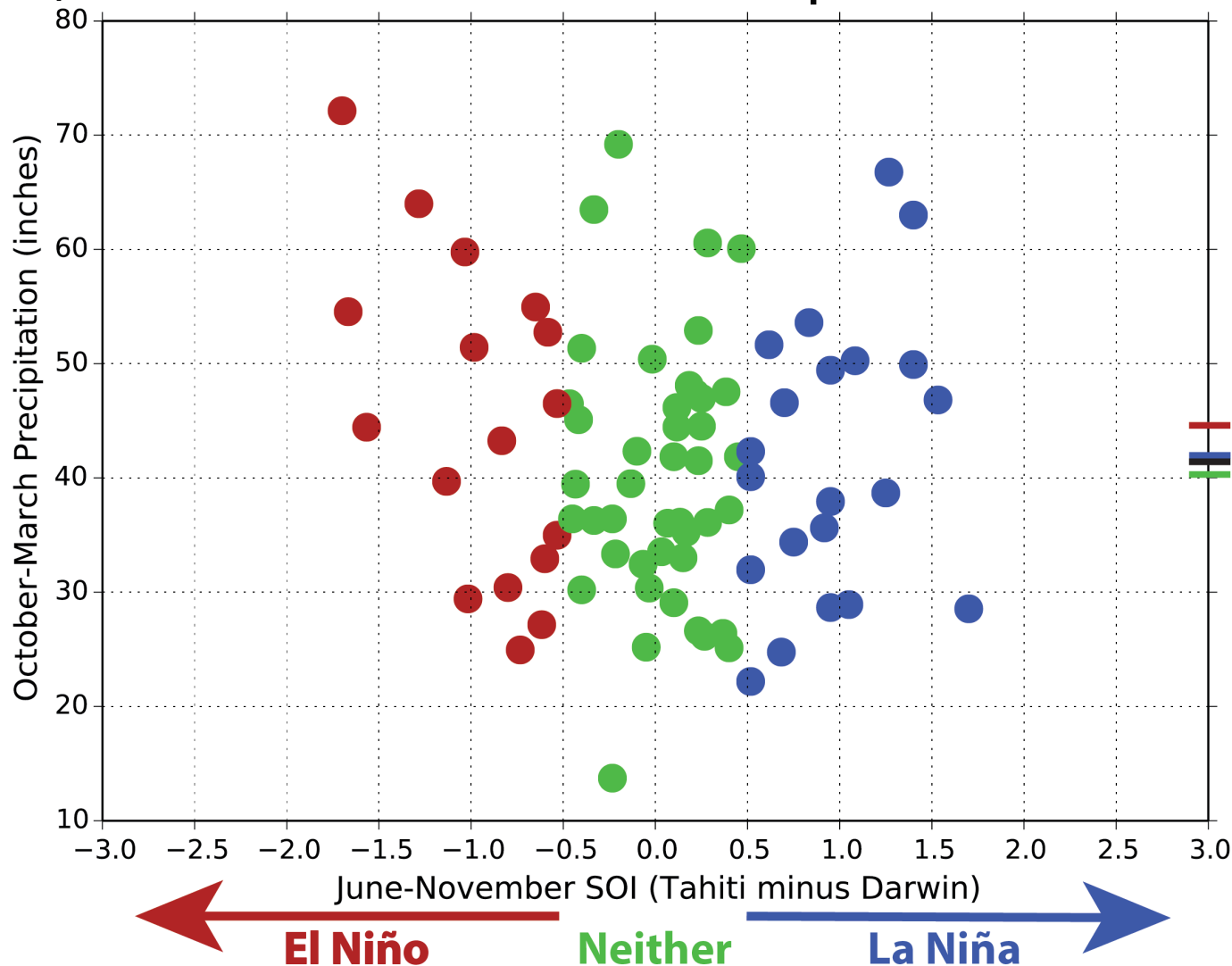
(versus Southern Oscillation Index for prior June - November)



Arizona

CA Division 1 October-March Precipitation

(versus Southern Oscillation Index for prior June-November)



**Years 1933/1934-
2013/2014**

$r^2 = 0.01$

Correlation = -0.11

Mean = 44.9 in

Mean = 41.53 in

Mean all = 41.51 in

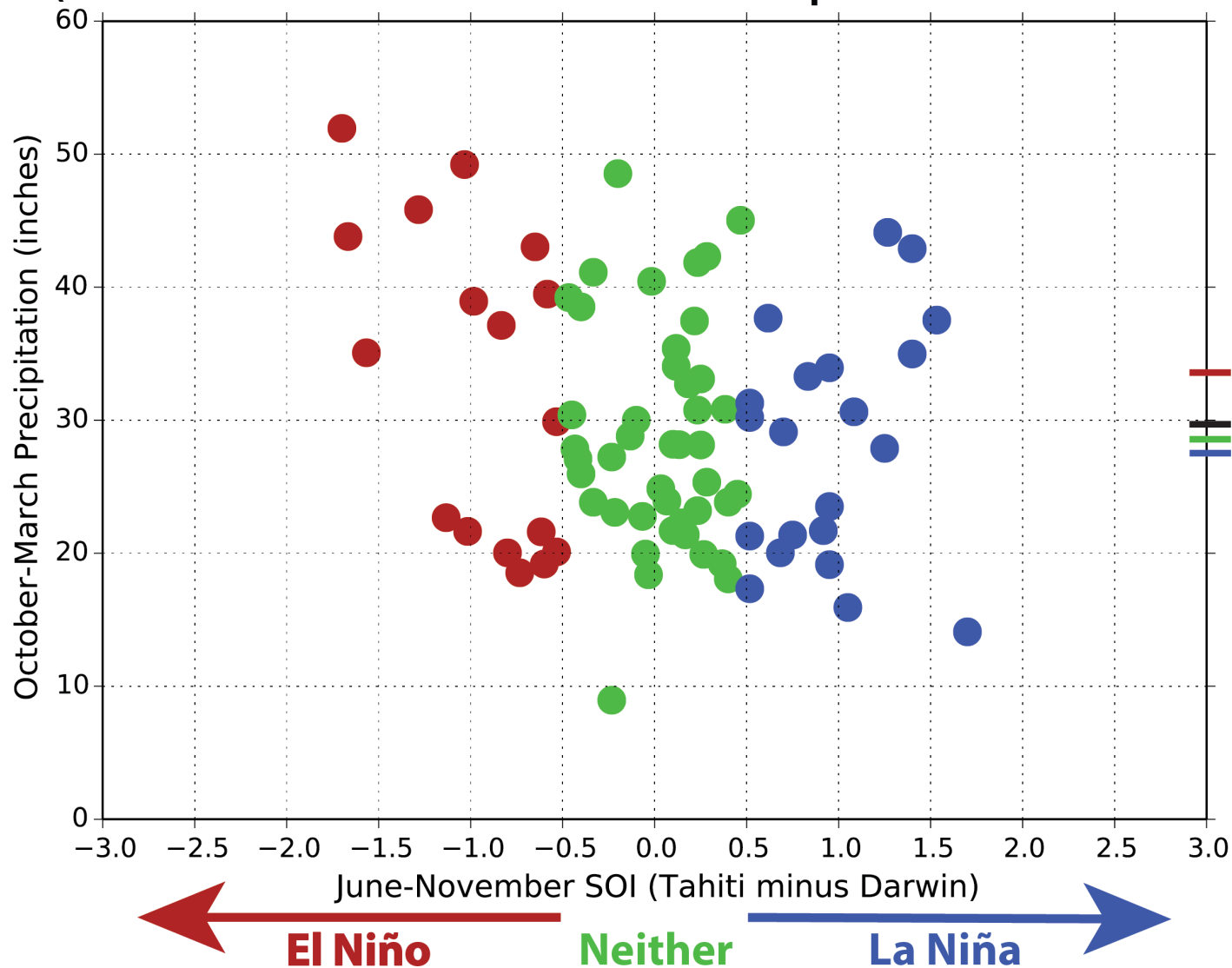
Mean = 40.15 in



Western Regional
Climate Center

CA Division 2 October-March Precipitation

(versus Southern Oscillation Index for prior June-November)



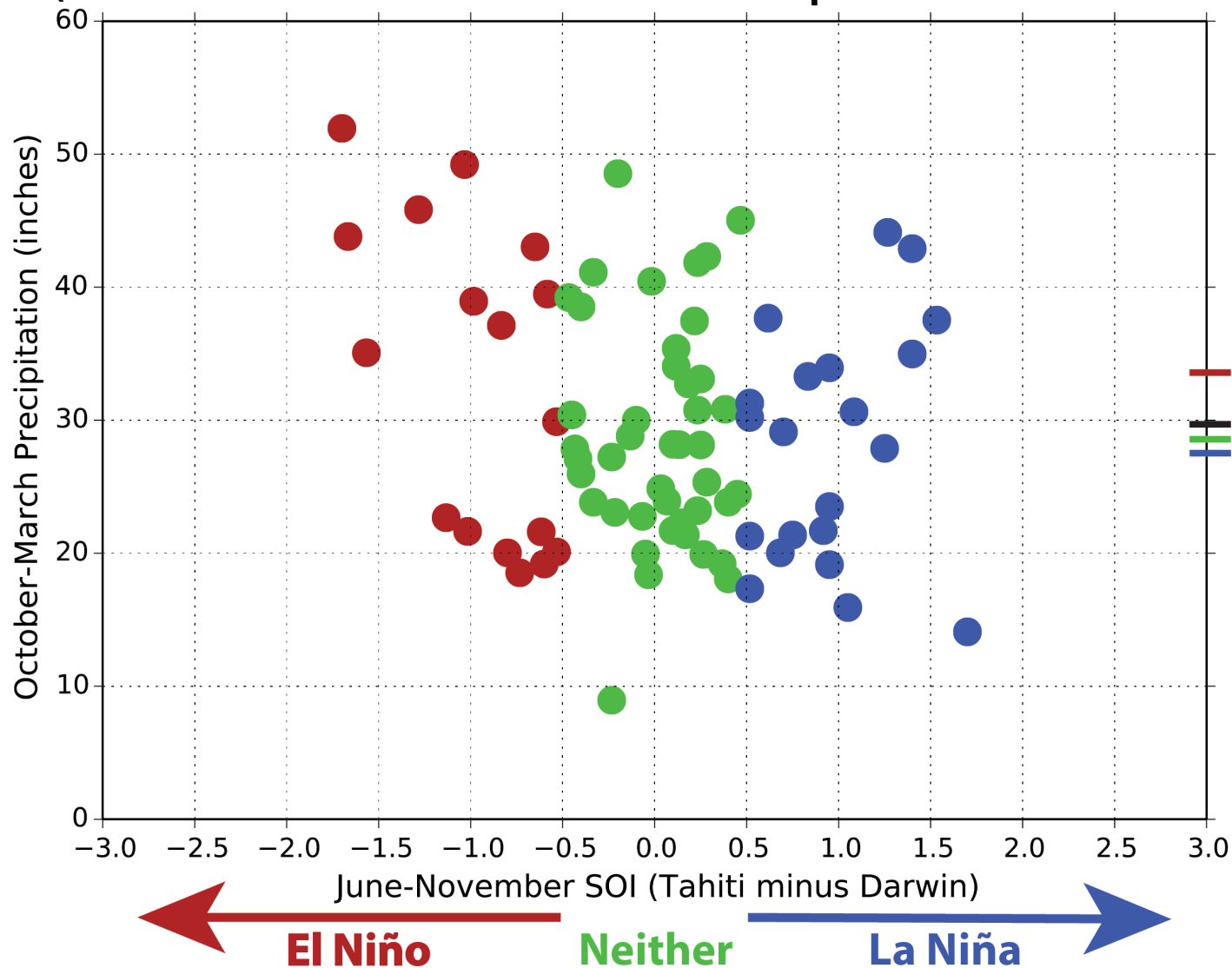
**Years 1933/1934-
2013/2014**
 $r^2 = 0.05$
Correlation = -0.22
Mean = 32.83 in
Mean all = 29.44 in
Mean = 28.8 in
Mean = 28.0 in



Western Regional
Climate Center

CA Division 2 October-March Precipitation

(versus Southern Oscillation Index for prior June-November)



**Years 1933/1934-
2013/2014**

$r^2 = 0.05$

Correlation = -0.22

Mean = 32.83 in

Mean all = 29.44 in

Mean = 28.8 in

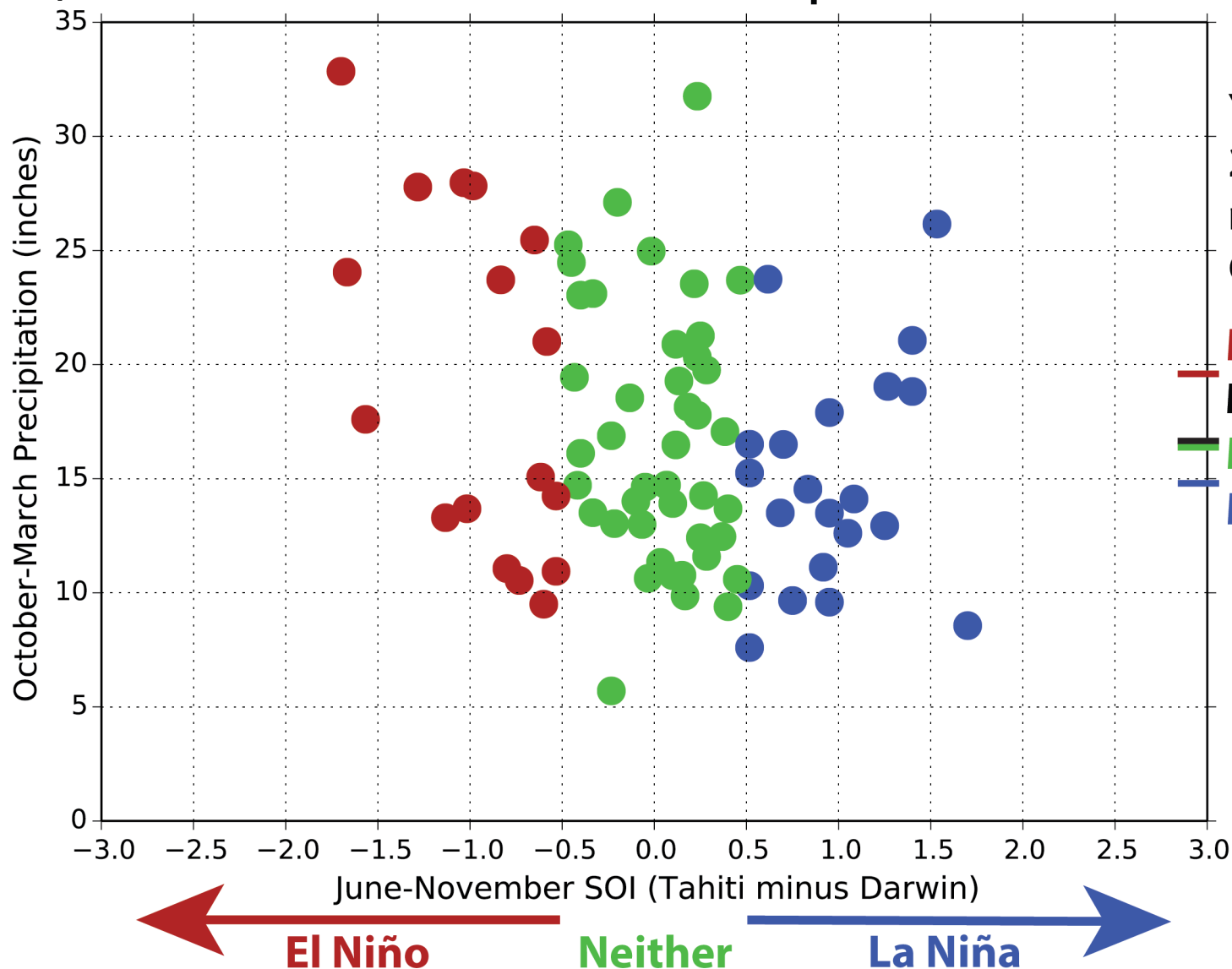
Mean = 28.0 in



Western Regional
Climate Center

CA Division 5 October-March Precipitation

(versus Southern Oscillation Index for prior June-November)



**Years 1933/1934-
2013/2014**

$r^2 = 0.09$

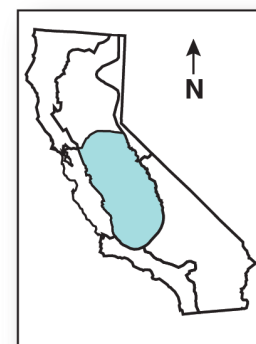
Correlation = -0.3

Mean = 19.21 in

Mean all = 16.83 in

Mean = 16.83 in

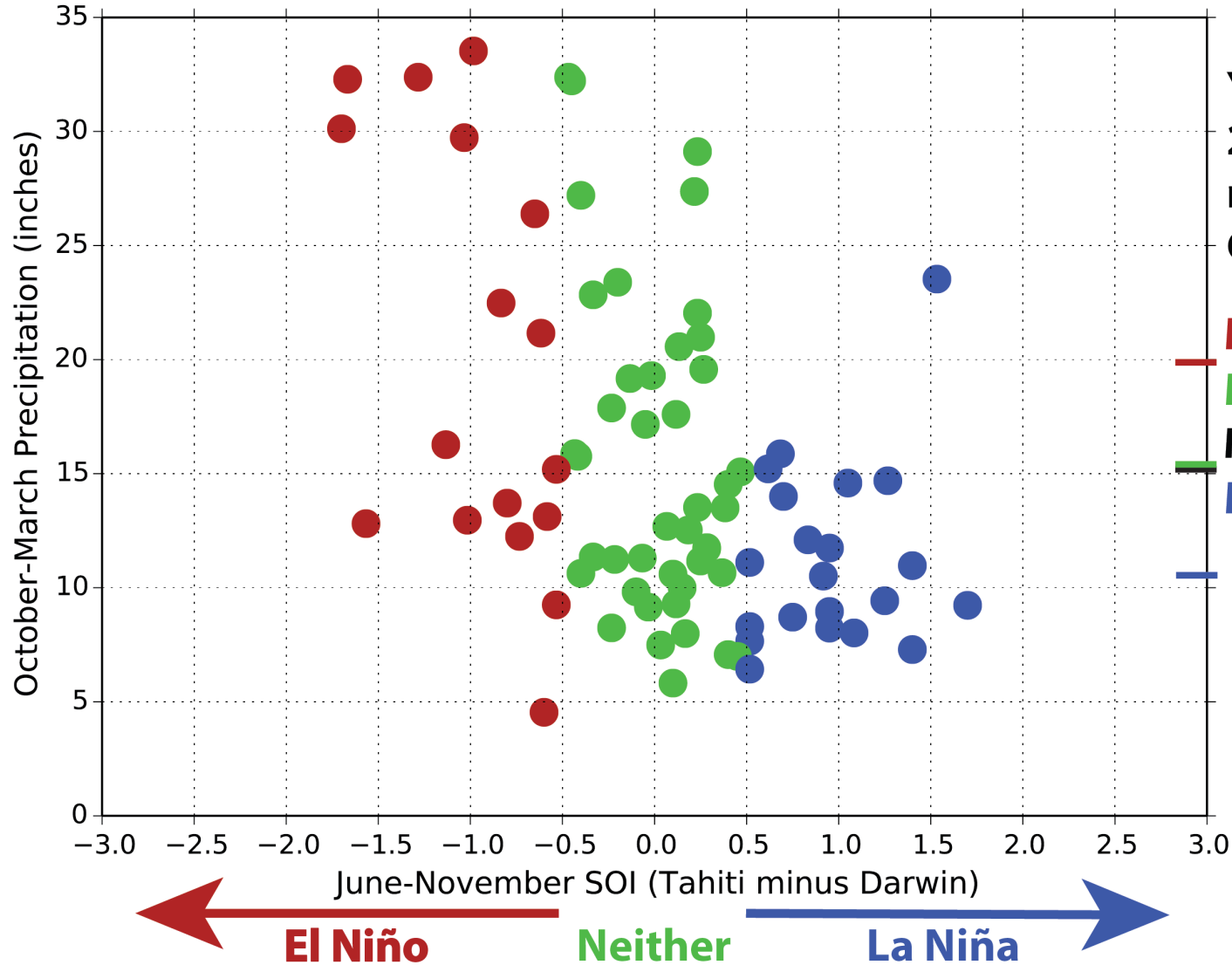
Mean = 14.91 in



Western Regional
Climate Center

CA Division 6 October-March Precipitation

(versus Southern Oscillation Index for prior June-November)



**Years 1933/1934-
2013/2014**

$r^2 = 0.22$

Correlation = -0.47

Mean = 19.89 in

Mean = 15.45 in

Mean all = 15.30 in

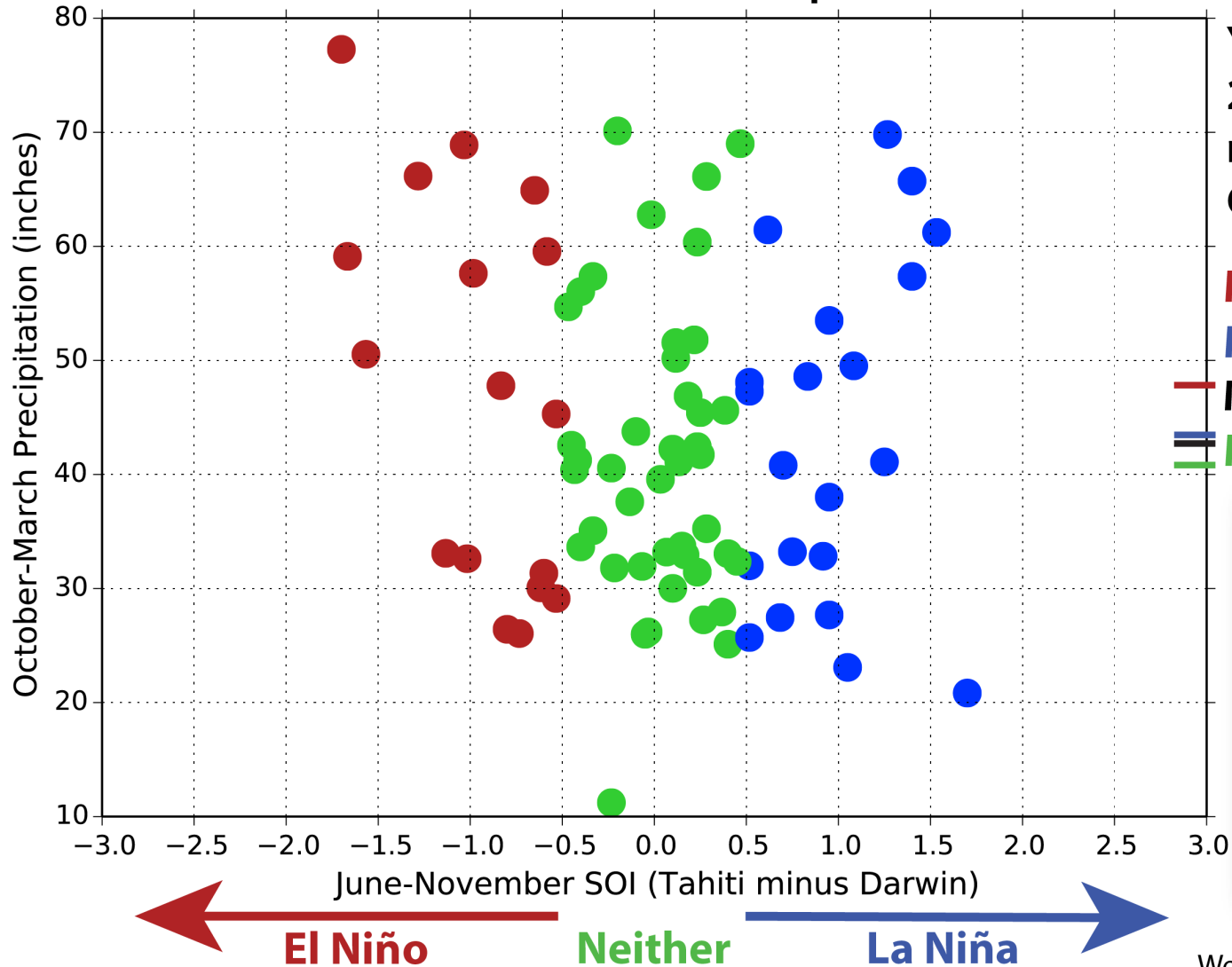
Mean = 11.27 in



Western Regional
Climate Center

CA 8-Station Index October-March Precipitation

(versus Southern Oscillation Index for prior June-November)



**Years 1933/1934-
2013/2014**

$r^2 = 0.02$

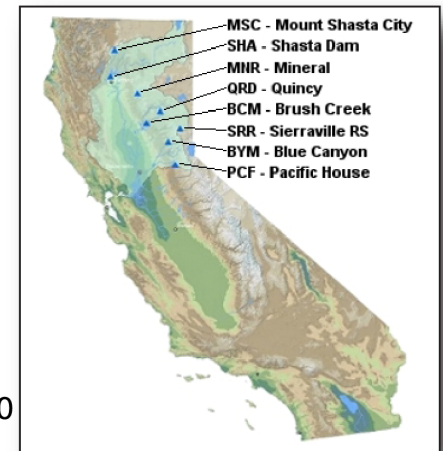
Correlation = -0.13

Mean = 47.4 in

Mean = 43.11 in

Mean all = 43.09 in

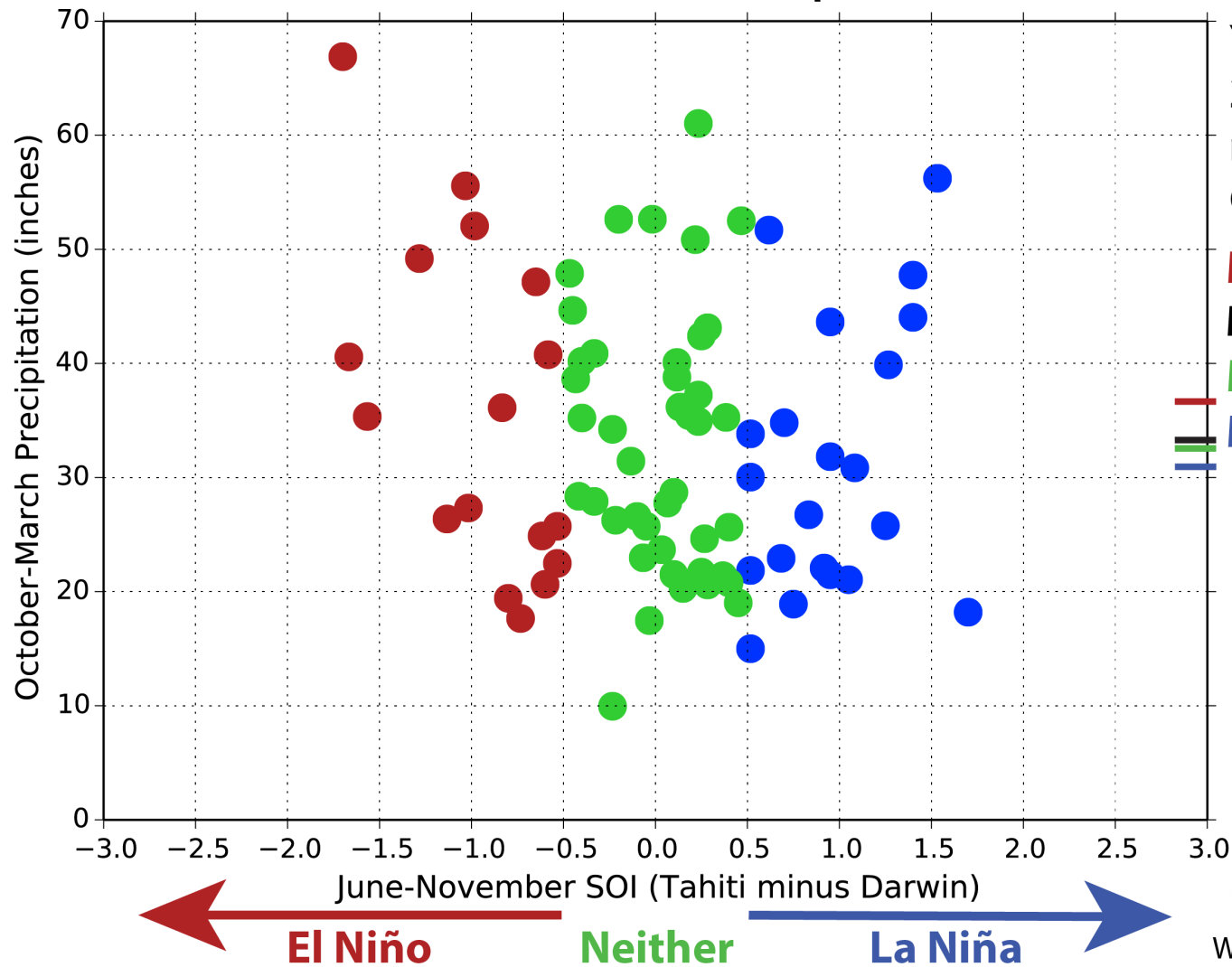
Mean = 41.38 in



Data Source: CA DWR
Western Regional Climate Center

CA 5-Station Index October-March Precipitation

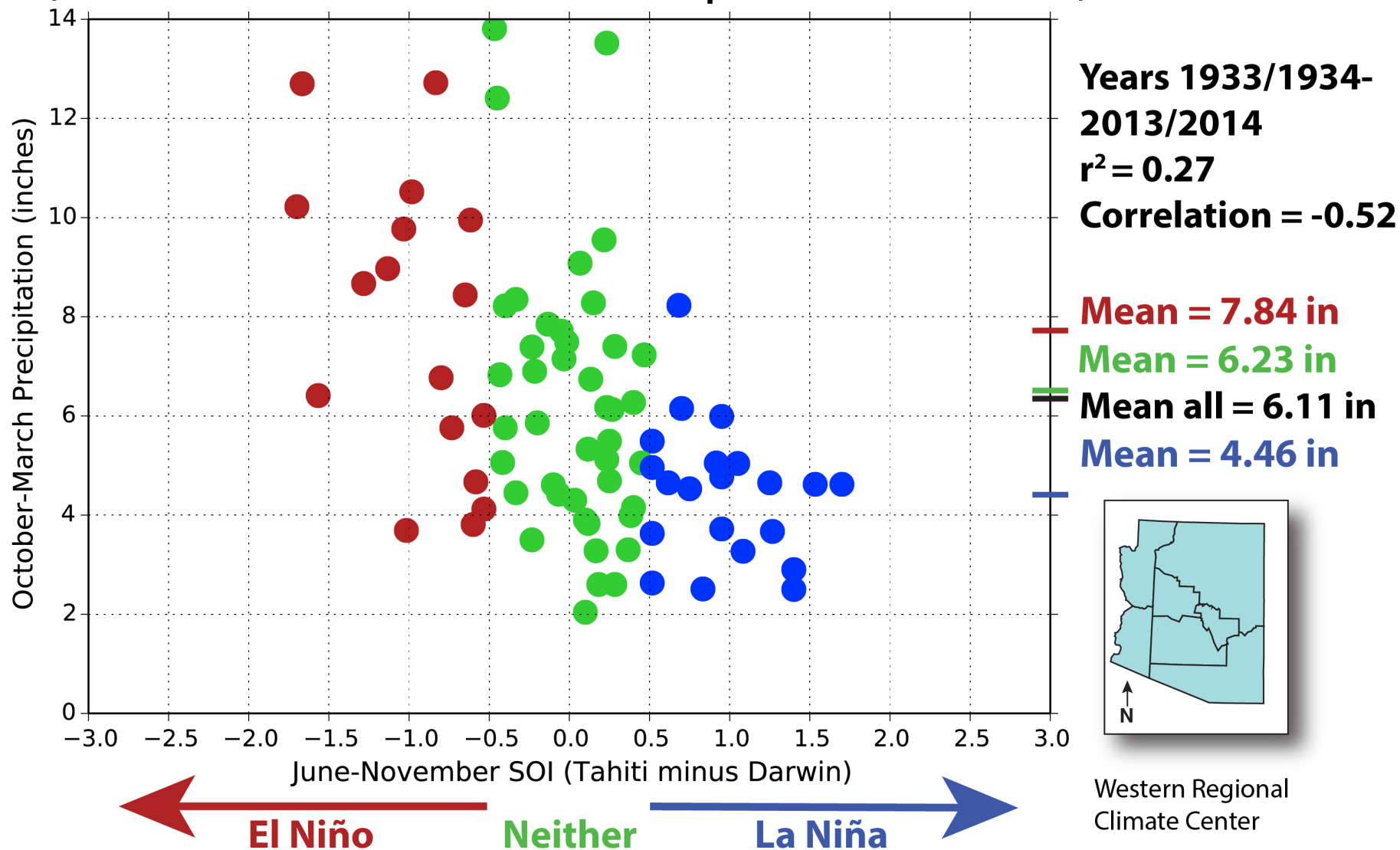
(versus Southern Oscillation Index for prior June-November)



Data Source: CA DWR
Western Regional Climate Center

Arizona Statewide October-March Precipitation

(versus Southern Oscillation Index for prior June-November)



Temperature & Precipitation Official Outlooks

Three Month Summer

2015

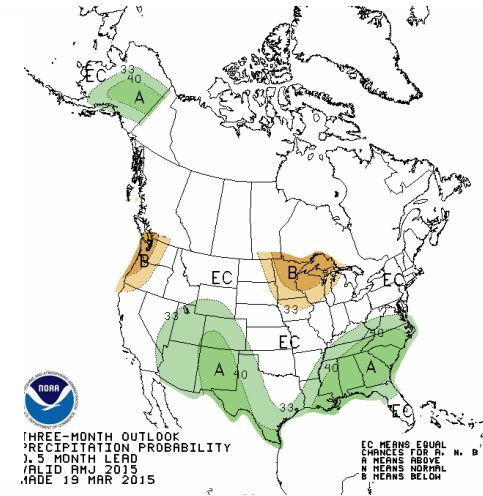
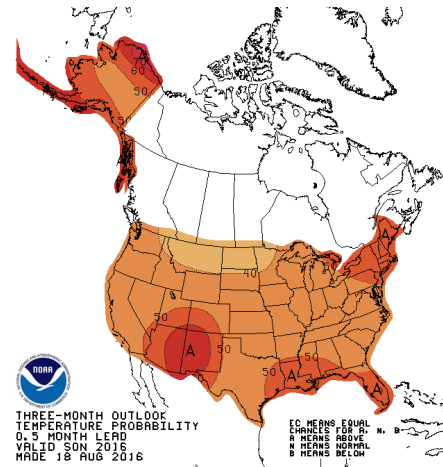
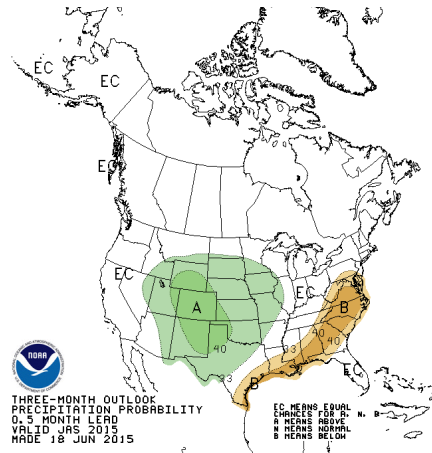
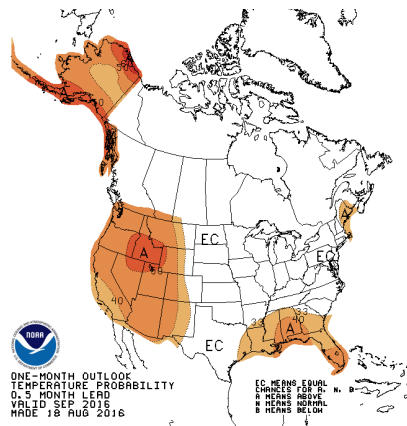
Three Month Winter

September T

September P

Sep-Oct-Nov T

Nov-Dec-Jan P



Orange / Red
Green

- Higher likelihood of drier than usual
- Higher likelihood of wetter than usual

NOAA Climate Prediction Center

Thank You !



**Mather RAWS Station
Great Basin Nat Park**